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SIZE, AGE COMPOSITION AND MIGRATION OF STRIPED BASS FROM THE SURF WATERS OF LONG ISLAND[1]

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ABSTRACT

Between June of 1961 and November of 1964, a total of 4,924 striped bass were netted from the ocean surf at Great South Beach (N.Y.) using a commercial haul seine. All specimens were measured and the ages of many were determined. Of these, 912 collected between June of 1961 and November of 1963 were tagged and released, more than half of which were of large size, i.e., 600 millimeters or more in fork length or 6 pounds or more in weight. In addition, 178 striped bass ranging from 300 to 600 millimeters in fork length, were tagged and released at Westhampton Beach (N.Y.) between November of 1954 and May of 1956. Length-frequency and age-frequency data for the tagged fish are given, and data for tag returns are presented and discussed in relation to the time and place of release, fish size, and the season, location and method of recapture. The results suggest that a substantial proportion of the striped bass tagged at Westhampton Beach may have been of Hudson River origin, while those tagged at Great South Beach, which mostly represented the 1958 and 1961 year classes, probably originated in Chesapeake and/or Delaware Bay. It was concluded that unrestricted fishing for the striped bass that occur seasonally along the south shore of Long Island might be warranted.

There are few published records of tagging programs focused on the migration patterns of large (either 6 pounds or more in weight or 600 millimeters or more in fork length) striped bass (*Roccus saxatilis*). So far as is known only Chapoton and Sykes (1961), working primarily in North Carolina and Chesapeake Bay, have reported specifically on the subject, although several striped bass migration experiments have been conducted in which at least some large individuals were tagged and released. These latter studies include those of Merriman (1941), Morgan and Gerlach (1950), Calhoun (1952), Vladykov and Wallace (1952), Raney *et al.* (1954), Mansueti (1961), Massmann and Pacheco (1961), Alperin (1966) and Nichols and Miller (1967). In addition to these, a few similar projects have been listed by Nichols and Cheek (1966).

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R. The author wishes to extend his sincere gratitude to all those members of the Federal Aid Fish Research Unit who contributed to this study. Special thanks are due to Irwin M. Alperin who, as biologist-in-charge of this investigation, initiated, designed and participated in the field operations at Great South Beach between 1961 and 1964 and, in addition, tabulated much of the data presented. Thanks are also due to Ralph Saturnino who prepared the graphs.

Moreover, while most tagging investigations on this species have been conducted in estuarine areas and river systems, only Merriman (1941), Vladykov and Wallace (1952) and Chapoton and Sykes (1961) reported marking and releasing striped bass in an outer beach surf environment. All of their researches were carried on with commercial haul-seine gear operated in the general area between Kitty Hawk and Oregon Inlet in North Carolina. A total of 687 specimens were tagged in this area; 600 (mostly 2 years olds but including some individuals 3 or 4 years of age) by Merriman, 6 (19 to 26 inches long) by Vladykov and Wallace and 81 (all of large size) by Chapoton and Sykes.

The research presented here was prompted by the general absence of information concerning the dispersal of striped bass from surf environments and the migration of large fish along the Atlantic coast of the United States. A compilation of three separate projects conducted in New York over an 11-year period (1954 through 1964), the report is centered on the size, age composition and migration of the species from the surf waters of long Island with particular emphasis on large fish. The major intent of the work was to augment previous tagging investigations on striped bass in New York (Neville, 1940; Merriman, 1941; Raney *et al.*, 1954; Alperin, 1966) and, further, to complement the research of Chapoton and Sykes (1961).

DESCRIPTION OF TAGGING SITES

Two similar ocean surf localities, both situated on the south shore outer barrier beach of Long Island were used as tagging sites (Figure 1).

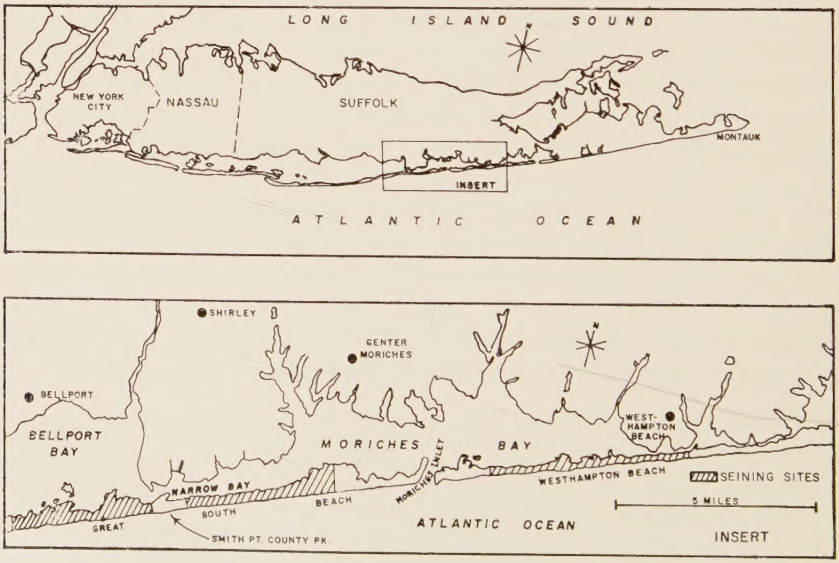

Figure 1. Location of striped bass tagging sites on Long Island.

One of these areas, Westhampton Beach, is located approximately 75 miles east of New York City. It extends for a distance of about 6 miles westward from the vicinity of the village of Westhampton Beach and is separated from the mainland by Moriches Bay. To the south is the open Atlantic. The beach itself, which at the time of the study was uninterrupted by rock groins or jetties, slopes gently for an average distance of approximately 300 feet from a landward line of high, grass-covered dunes to the waterline. Immediately north of the dune line is a public thoroughfare, suitable for nearly all automobile traffic, which extends for the entire length of the beach parallel to the waterline. This road permits access to the beach at many locations.

The other tagging site, located west of Moriches Inlet, was situated along a 7-mile stretch of Great South Beach (commonly known as Fire Island) extending approximately 3½ miles east and 3½ miles west of Smith Point County Park. Great South Beach itself, which is fully exposed to the open Atlantic to the south and is isolated from the mainland by Great South, Bellport, Narrow and Moriches Bays to the north, extends from Fire Island Inlet approximately 32 miles eastward to Moriches Inlet. The area is repetitious of the Westhampton Beach tagging site in that it is generally characterized by a fairly broad, sandy shoreline to seaward and an adjacent series of high, vegetation-covered sand dunes to landward. Moreover, except for jetties in the inlet areas, there are no rock groins anywhere along the entire expanse of beach to shelter it from the full effects of the longshore currents and pounding surf. However, there is no public thoroughfare paralleling the beach at this site and, therefore, access is limited. The area has previously been described in greater detail by Snyder (1963) and Schaefer (1967).

METHODS AND MATERIALS

The methods employed in carrying on the study at the two tagging sites differed in some respects. Therefore, they are described separately.

Westhampton Beach, 1954 to 1956

Between November 9 and 17 in 1954, between October 27 and November 25 in 1955, and on May 24 in 1956 striped bass were tagged and released in the ocean surf at Westhampton Beach. The fish were obtained directly from commercial fishermen operating in the area which, at that time, supported an extensive haul seine fishery for the species. On scheduled tagging dates, Conservation Department personnel travelled by automobile along the road adjacent to the dune line. Stops were made at various intervals, and the horizon was scanned with binoculars from the top of the dunes to locate any seining crews in operation. When a crew was located, the automobile was driven as close as possible to their position and the tagging gear was then carried over the dunes and

across the beach to the seining site. There, permission was obtained from the crew leader to receive all sublegal (less than 16 inches in fork length) striped bass that were captured. When these were not available in sufficient quantity, additional, legal-sized fish were purchased at the wholesale market price. In general, only small fish were purchased so that a maximum number could be obtained at the least cost.

The fish were placed in a 20-gallon galvanized steel tub which was filled by carrying sea water from the surf in pails. Each fish was measured to the nearest one-quarter inch in fork length, tagged and then released immediately into the surf. In addition to the length of the fish, the date, tag number and tagging location were recorded.

Two types of tag were used: (1) Petersen and (2) mandible split ring and pennant. The Petersen tag consisted of two ½-inch-diameter cellulose acetate disks (one red and one white, each 0.025 inch thick, appropriately printed and serially numbered) and either a stainless steel or nickel 1¾-inch pin. This tag was affixed to the body of the fish through the musculature approximately 1 inch below the mid-dorsal ridge and midway between the first and second dorsal fins. The mandible split ring and pennant tag, similar to that described by Vladykov (1957), consisted of a ¾-inch or 1-inch monel split ring with plastic dangler (1 inch long, 9/32 inch wide and 0.06 inch thick with an 0.08-inch hole punched in one end and appropriately printed) attached. This tag was affixed to the fish by opening the split ring with specially designed pliers and placing it around the left mandible. Good illustrations of each type of tag and its method of attachment were given by Webster (1955). The type of tag employed (and the size of the split ring used in the mandible tag) on any fish was determined by the size of the specimen and the judgment of the tagging personnel. In several instances both the Petersen and mandible split ring and pennant tags were used on the same fish. In all cases a reward of one dollar was offered for the return of each tag. Information concerning the location, date and method of recapture was requested from the sender when these data were not supplied with the original return of the tag.

Great South Beach, 1961 to 1963

Striped bass were tagged at the Great South Beach site between June 27 and November 30 in 1961, between May 8 and October 25 in 1962, and between May 6 and November 22 in 1963. The collecting gear used was a modified 1,300 by 12½-foot commercial nylon beach seine of the following specifications: outer wings, each 550 feet long and comprised of 6-thread, 3-inch stretch webbing; inner wings or bunt, each 90 feet long and comprised of 12-thread, 2-inch stretch webbing; bag or "cod end", 25 feet deep and comprised of 15-thread, 1½-inch stretch webbing with a mouth 20 feet wide. Operating methods and

tagging dates (except for June 27, 28 and 29 in 1961) have been previously reported by Schaefer (1967).

At this location, when the "cod end" of the seine had been beached, the fish were transferred immediately by scap net to a canvas holding tank, 4 feet long by 2½ feet wide by 3½ feet deep, erected on the beach above the highwater mark. This tank was tied to and supported by four ⅜-inch iron pipes 5 feet long that were driven approximately 1½ feet into the sand, one at each corner. Early in the program the holding tank was filled by carrying sea water from the surf is pails. Because of the obvious disadvantages of this procedure, a system was devised to provide a continuous flow of running sea water to the holding tank (Schaefer, 1965). The holding tank and sea water system are illustrated in Figure 2.

Each fish was removed from the holding tank and weighed to the nearest whole ounce on a 60-pound-capacity Chatillon 8-inch-dial scale. To prevent physical injury to the fish, weighing was accomplished by placing the specimen in a 10-gallon plastic bucket (the bottom of which had been drilled with eighteen 9/32-inch holes to permit the drainage of any water) suspended from the scale by four 18-inch brass chains. The scale, which was preadjusted to read zero with the empty bucket and chains, was in turn, suspended from a 6-foot collapsible wooden quadripod erected on the beach (Figure 3). The weight was read and recorded when the fish was at rest and the dial of the scale had stabilized.

After weighing, each fish was measured to the nearest 5 millimeters in fork length on a 1,200-millimeter capacity standard measuring board. If age information was desired, approximately 10 to 12 scales were removed at this time from the left side of the body above the lateral line between the two dorsal fins and placed in a labeled coin envelope for future processing and examination in the laboratory. If a fish was selected for tagging, two ⅝-inch-diameter cellulose acetate Petersen disks (one red and one white, each 0.025 inch thick, appropriately printed and serially numbered) were affixed with a 3-inch stainless steel pin to the same body area as that selected for this tag in the program at Westhampton Beach. After the tag number and tagging location were recorded, the fish was immediately released into the adjacent surf. As in the earlier work, a reward of one dollar was offered for the return of each tag, and information on location, date and method of recapture was requested if not included with the original return.

Although all striped bass captured were weighed and measured, scale samples were not removed from every fish and all fish were not tagged. In 1961, for example, scales were taken only from those fish which were tagged. Thereafter, in 1962 and 1963, scales were removed from all fish except on certain days when individual catches were so large that this was impractical. On these occasions, scale samples were taken from all fish to be tagged, but only from a representative sample

Figure 2. Transferring striped bass from scap net to canvas holding tank supplied with running sea water.

Figure 3. Striped bass being weighed in plastic bucket suspended from quadripod.

(by length) of the remainder. Moreover, early in the period (between June 27 and August 25 in 1961) all captured striped bass were tagged regardless of size. Thereafter, except for a few slightly smaller specimens tagged in August and September of 1961, only fish 600 millimeters or more in fork length or 6 pounds or more in weight were tagged during the remainder of the study.

At the laboratory, some six to eight scales were selected from each scale sample and mounted on 0.05-inch transparent cellulose acetate. Using a Carver laboratory press (Model B), scale impressions were made on the acetate. The impressions were viewed at a magnification of 27× on an Eberbach reflex microprojector, annuli were identified according to the criteria of Scofield (1931) and Merriman (1941), and ages were determined.

Ages were determined for all the striped bass that were tagged. Ages were not determined, however, for all non-tagged striped bass (those less than 600 millimeters in fork length or less than 6 pounds in weight) from which scales were taken in 1962 and 1963. Only in those months when samples were relatively small (September and October in 1962, July and September in 1963) were all specimens aged. In other months when relatively large numbers of non-tagged individuals were collected, smaller, representative subsamples were chosen for aging. This was accomplished by grouping the specimens by month in 100-millimeter categories according to the length of the fish from which they came. Then, for a particular month, equal percentages (arbitrarily established at either 25 per cent if the monthly catch was 200 fish or more, or 50 per cent if the monthly catch was less than 200 fish) were selected at random from each category. Monthly age-composition estimates were subsequently derived from all striped bass by extrapolating the date for the subsamples for non-tagged fish and combining these figures with the data for tagged fish. Figures for each year were derived by summing the monthly date.

Great South Beach, 1964

On 31 dates between April 27 and November 24 in 1964, seining was conducted for striped bass at the Great South Beach site using the same gear and netting techniques employed during the 1961-1963 program. Operations were carried out for a maximum of two days per week. Although seining dates were scheduled to occur consecutively each week begining on Monday, unfavorable weather and surf conditions often prevented operations on either or both of these days or, indeed, on any day during certain weeks. Following capture, all fish were measured to the nearest 5 millimeters in fork length, but scale samples were removed only from those 600 millimeters or more in length. The scales were taken from the same body area, stored, processed and read in the same manner as those taken during the 1961-1963 period. But no fish were tagged.

SIZE AND AGE COMPOSITION

All striped bass collected from the surf between 1954 and 1964 were assigned to 25-millimeter length categories and, where feasible, monthly and annual length-frequency and age-frequency distributions were calculated for both tagged and untagged fish. Migration data were tabulated and charted with reference to season[2], location and method of recapture.

1954 to 1956

During these years, 178 striped bass, ranging from 300 to 600 millimeters in fork length, were tagged at Westhampton Beach. Monthly length-frequency distributions of these fish are presented in Figure 4. As indicated by these graphs, more than 90 per cent of the tagged fish were between 400 and 500 millimeters long. No age data are available for these fish, but based on age-length observations of Merriman (1941) for New England and Mansueti (1961) for Chesapeake Bay it seems reasonable to assume that the specimens were mostly 3-, 4- and 5-year-old fish.

1961 to 1963

A total of 4,137 striped bass were collected at Great South Beach. Of these, 728 were captured in 1961, 1,149 were captured in 1962 and 2,260 were captured in 1963. Although the specimens ranged in size from as small as 200 millimeters in May of 1963 to as large as 1,175 millimeters in September of 1961 and in June and October of 1962, monthly and annual length-frequency distributions indicate that most of them were between 400 and 600 millimeters in length (Figures 5 to 8). More than 70 per cent of all striped bass collected each year were included in this size category. Only 4 to 12 per cent of the annual catches were less than 400 millimeters in length, a size which approximates the minimum legal retention limit of 16 inches in New York, while 10 to 16 per cent were more than 600 millimeters in length.

Monthly and annual age-frequency distributions of striped bass collected in 1962 and 1963 are presented in Figures 9 to 11. Since the age information available for fish collected in 1961 was not representative of the over-all population, these data have been omitted. The data for 1962, however, indicate that, while, striped bass ranged in age from 2 to 15 years, 4 year olds (1958 year class) were dominant, constituting nearly 60 per cent of the annual catch. In 1963, when ages ranged from 2 to 18 years, the strength of the 1958 year class was again reflected in the abundance of 5-year-old fish. It was obvious, however, that the 1958 year class was being replaced as the dominant group by another year class (1961) in late 1963 as indicated by the abundance of 2 year olds in October and November of that year. Indeed, 2-year-old fish comprised more than 40 per cent of all specimens taken in 1963 (Figure 11).

[2] According to celestial calendar, i.e., spring = March 21 - June 21, etc.

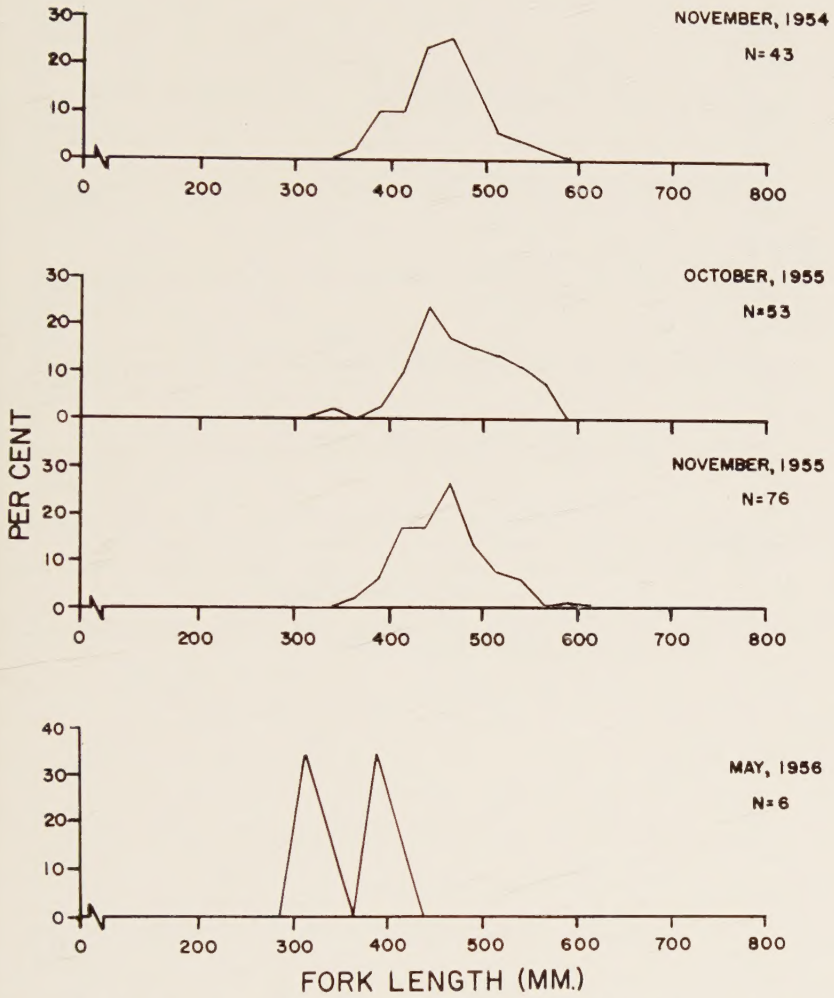

Figure 4. Monthly length-frequency distribution for striped bass tagged at Westhampton Beach in 1954, 1955 and 1956.

A total of 912 striped bass were tagged during the 3-year period, 407 in 1961, 134 in 1962 and 371 in 1963. Monthly and annual length-frequency distributions of these fish are presented in Figures 12 to 15. Except for the small fish tagged in 1961, most tagged specimens were between 600 and 800 millimeters in length. These fish were generally 4 to 9 years of age and represented the year classes of 1953 through 1958 (Figures 16 to 19).

1964

In this year, 787 striped bass were collected at Great South Beach.

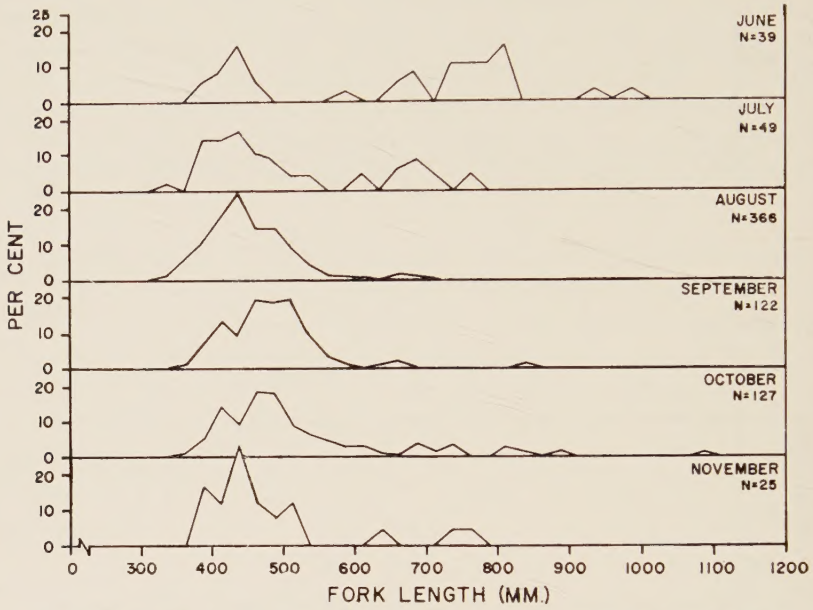

Figure 5. Monthly length-frequency distribution for striped bass collected at Great South Beach in 1961.

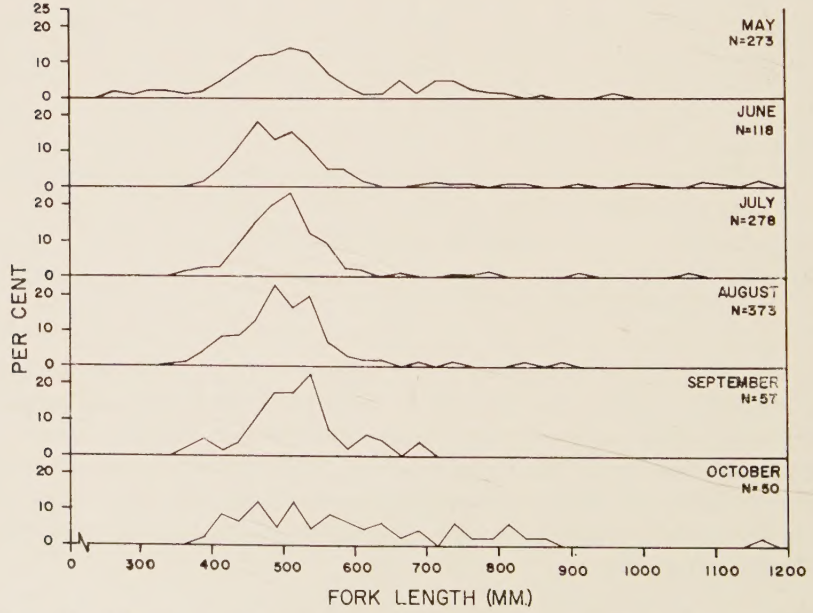

Figure 6. Monthly length-frequency distribution for striped bass collected at Great South Beach in 1962.

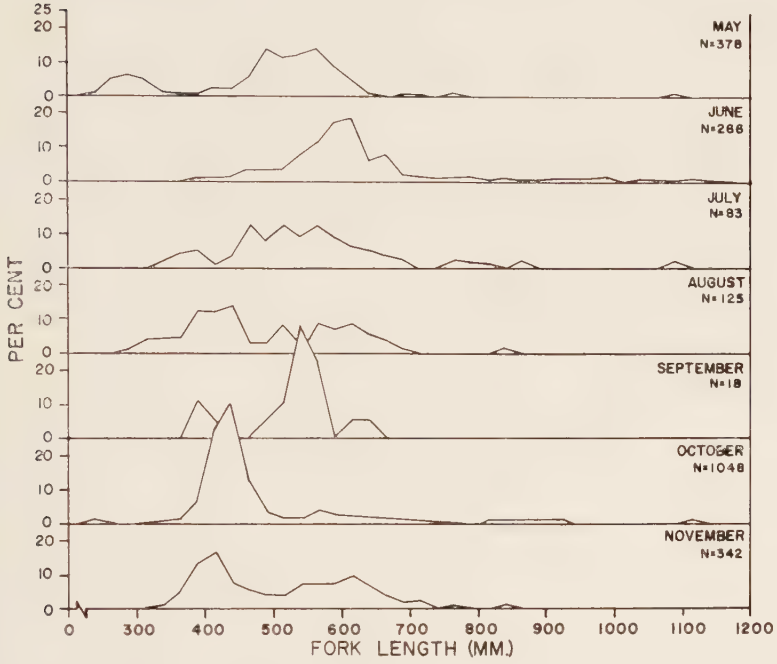

Figure 7. Monthly length-frequency distribution for striped bass collected at Great South Beach in 1963.

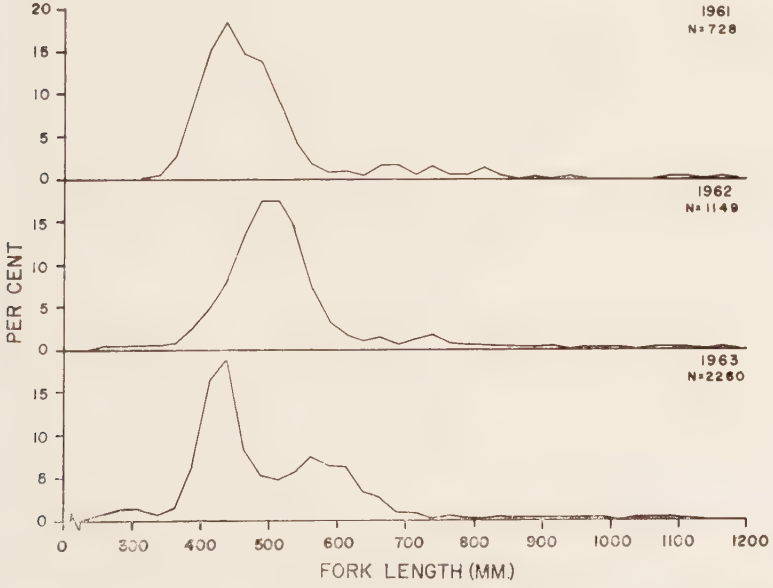

Figure 8. Annual length-frequency distribution for striped bass collected at Great South Beach in 1961, 1962 and 1963.

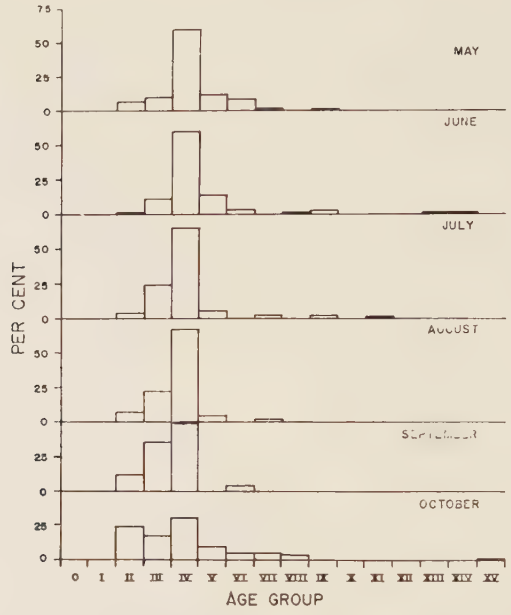

Figure 9. Monthly age-frequency distribution for striped bass collected at Great South Beach in 1962.

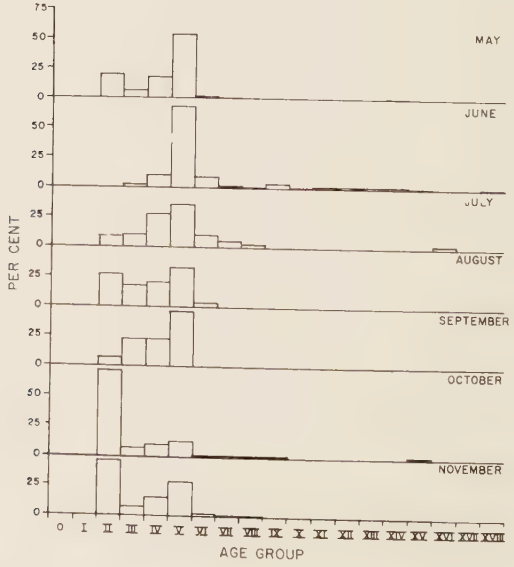

Figure 10. Monthly age-frequency distribution for striped bass collected at Great South Beach in 1963.

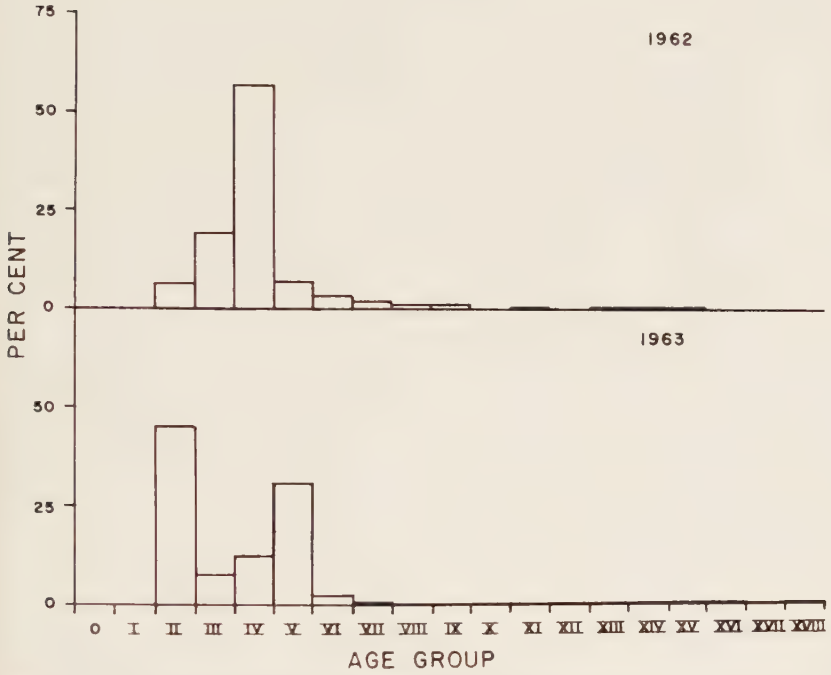

Figure 11. Annual age-frequency distribution for striped bass collected at Great South Beach in 1962 and 1963.

Monthly and annual length-frequency distributions (Figures 20 and 21) indicate that while sizes ranged from less than 300 millimeters to nearly 1,000 millimeters, modal lengths generally occurred between 400 and 500 millimeters. No age data are available for these fish.

Scale samples were taken and ages were determined for 168 specimens 600 millimeters or more in fork length. These data are presented as length- and age-frequency distributions, respectively, in Figures 22 and 23. While ages ranged from 4 to 10 years, most fish were between 4 and 7 years old, and 6 year olds (1958 year class) occurred most frequently.

TAG RETURNS

Tag returns provided information on the seasonal distribution of striped bass occurring in Long Island waters. They are summarized according to the year in which the tagging was done.

1954 TO 1956

Of the 178 striped bass tagged during these years at Westhampton Beach, 50, or 28.1 per cent, were recaptured (Table 1). While only 10 per cent of the recovered fish were taken in New England waters, more than 50 per cent were recaptured in New York waters and 34 per cent were taken from waters to the south of New York (Table 2). Moreover,

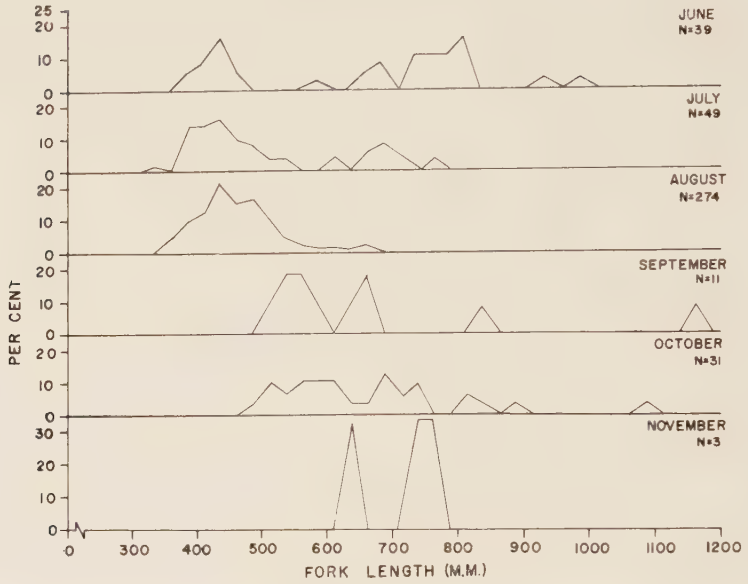

Figure 12. Monthly length-frequency distribution for striped bass tagged and released at Great South Beach in 1961.

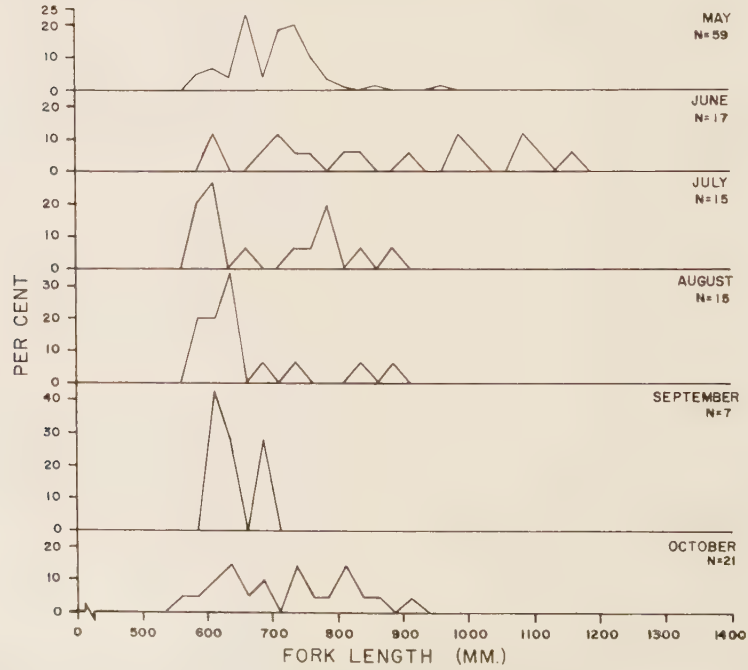

Figure 13. Monthly length-frequency distribution for striped bass tagged and released at Great South Beach in 1962.

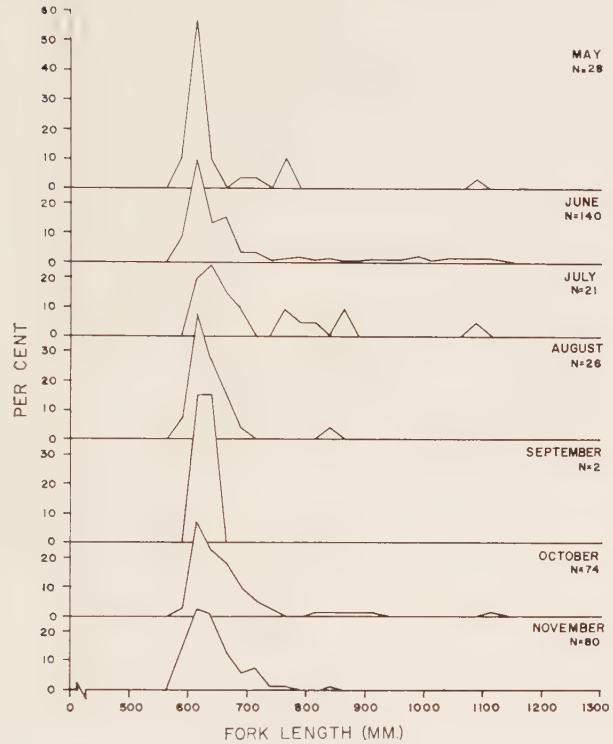

Figure 14. Monthly length-frequency distribution for striped bass tagged and released at Great South Beach in 1963.

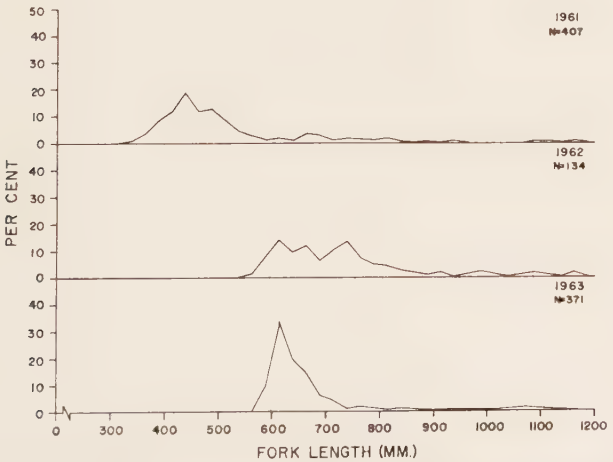

Figure 15. Annual length-frequency distribution for striped bass tagged and released at Great South Beach in 1961, 1962 and 1963.

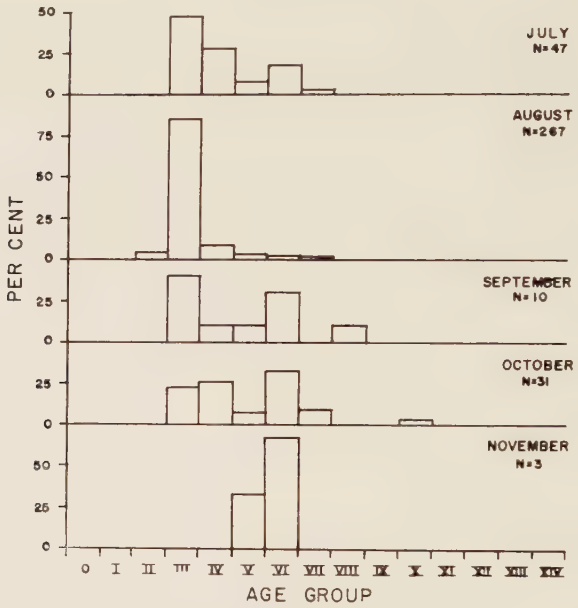

Figure 16. Monthly age-frequency distribution for striped bass tagged and released at Great South Beach in 1961.

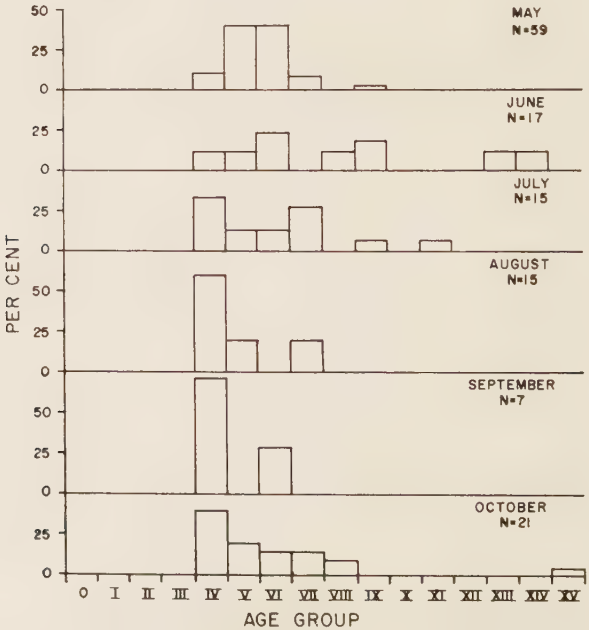

Figure 17. Monthly age-frequency distribution for striped bass tagged and released at Great South Beach in 1962.

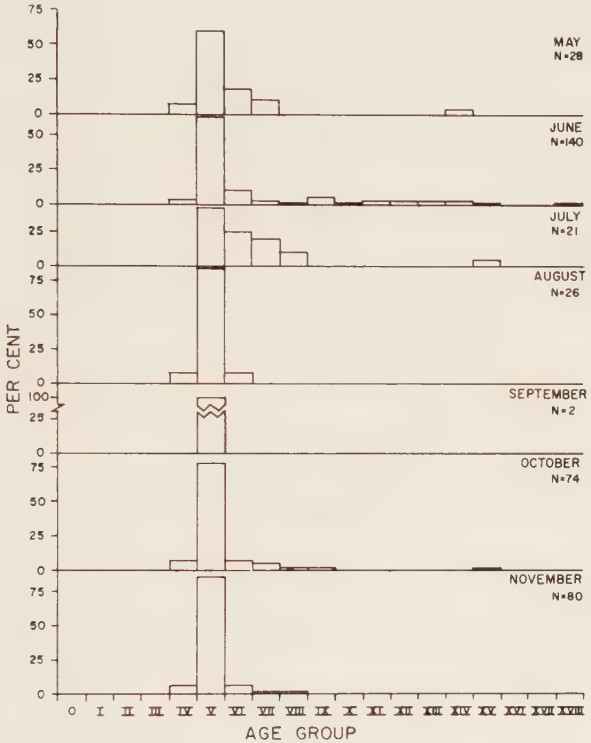

Figure 18. Monthly age-frequency distribution for striped bass tagged and released at Great South Beach in 1963.

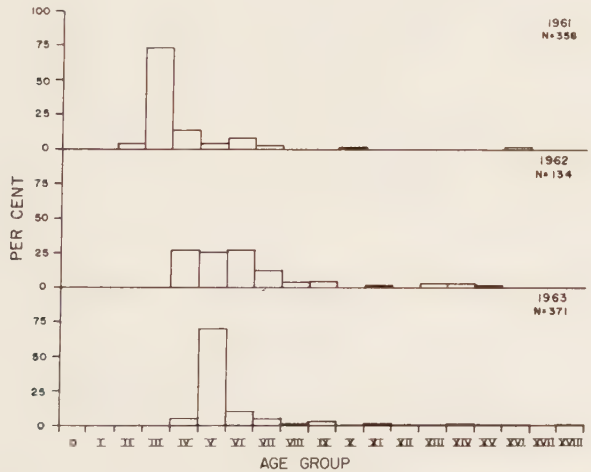

Figure 19. Annual age-frequency distribution for striped bass tagged and released at Great South Beach in 1961, 1962 and 1963.

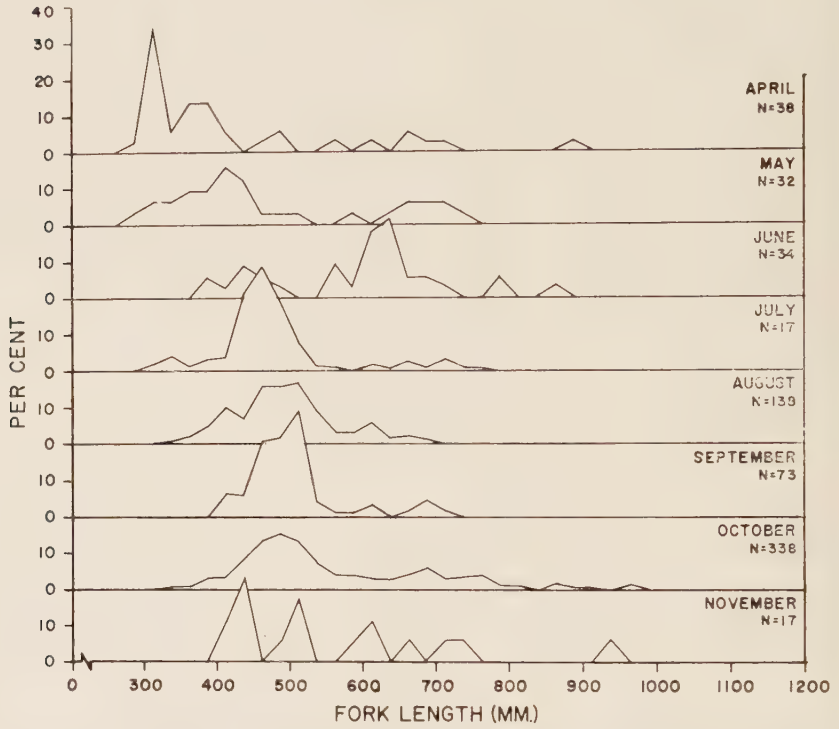

Figure 20. Monthly length-frequency distribution for striped bass collected at Great South Beach in 1964.

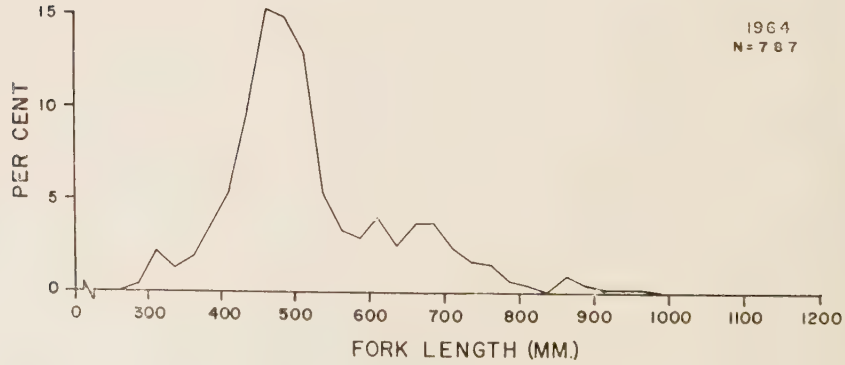

Figure 21. Length-frequency distribution for striped bass collected at Great South Beach in 1964.

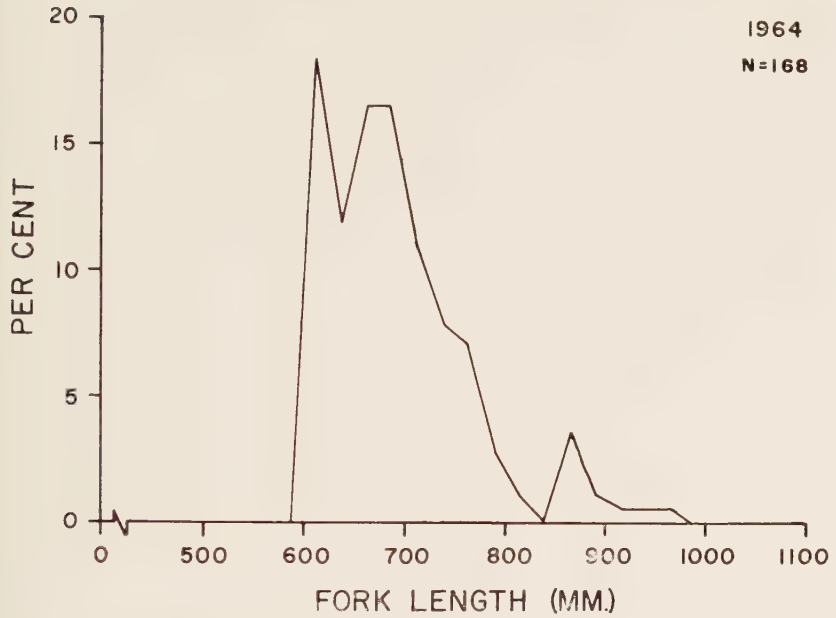

Figure 22. Length-frequency distribution for 168 large striped bass collected at Great South Beach in 1964.

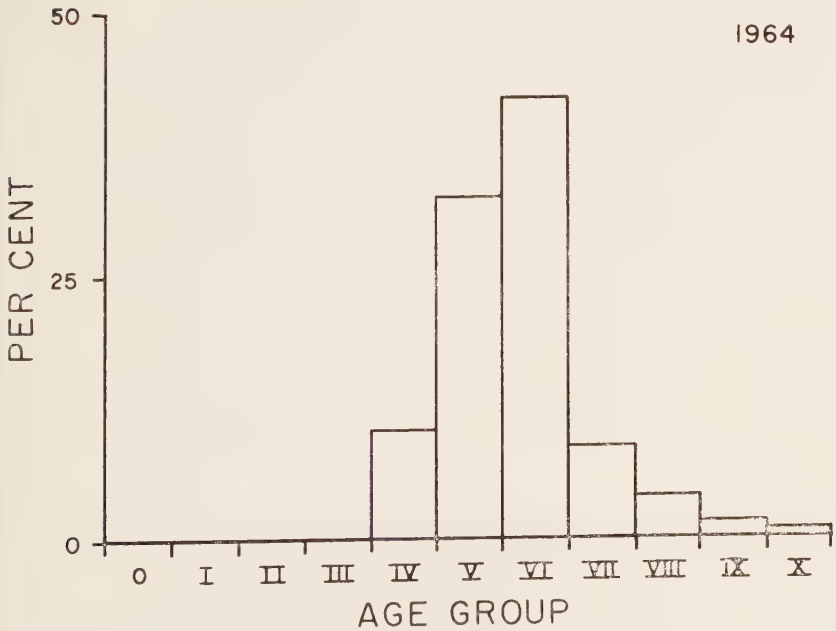

Figure 23. Age-frequency distribution for 168 large striped bass collected at Great South Beach in 1964.

Table 1. Summary of Records for Striped Bass Tagged at Westhampton Beach

Year tagged	Month tagged	Number tagged*	Recoveries	
			Number	Per cent
1954	November	43§	12	27.9
1955	October–November	129†	37	28.7
1956	May	6‡	1	16.7
Total		178	50	28.1

* See text for description of tags used.
§ Of these, five were tagged with jaw tags and 22 with Petersen discs. Of the latter, nine were attached with stainless steel pins and 13 with nickel pins. The other 16 were tagged with both jaw tags and Petersen discs, the latter being attached with stainless steel pins in 11 cases and with nickel pins in five cases.
† Of these, 72 were tagged with jaw tags and 57 with Petersen discs. Of the latter, 33 were attached with stainless steel pins and 24 with nickel pins.
‡ These were all tagged with jaw tags.

it is of interest that, of all fish recovered in New York, more than half came from the Hudson River.

The manner of recovery is summarized in Table 3. Nearly 70 per cent of the fish were taken by commercial fishing, while the remainder were taken by recreational fishing.

The geographical distribution of these recoveries by season is listed in table 2 and charted in Figures 24 to 27. An examination of these data suggests that most striped bass tagged at Westhampton Beach wintered well to the south of New York, especially in the vicinity of Delaware Bay and Chesapeake Bay (Figure 24). Spring recoveries (Figure 25), however, indicated that, of 25 fish recaptured during this season, 18 (72 per cent) were recovered from the Hudson River. Only one spring recovery was made north of New York, while six were made to the south. Summer recoveries were few, but all (except for one unknown) came from New York and northward (Figure 26), while fall recovery areas extended from New York south to Maryland (Figure 27). Specific recovery locations are listed by months in Table 4.

1961 to 1963

Data for the small fish tagged in 1961 were analyzed separately from those for the larger fish tagged during that and the following two years.

Small Fish A total of 332 striped bass less than 6 pounds in weight or 600 millimeters in fork length were tagged at Great South

TABLE 2. SEASONAL AND GEOGRAPHIC DISTRIBUTION OF RECOVERIES OF STRIPED BASS TAGGED AT WESTHAMPTON BEACH, 1954–1956

Location	Season				Total	
	Winter	Spring	Summer	Fall	Number	Per cent
North of New York						
North Atlantic	1	..	..	..	1	2.0
Massachusetts	..	1	2	..	3	6.0
Rhode Island	..	..	1	..	1	2.0
Sub-total	1	1	3	..	5	10.0
New York						
Long Island	..	5	1	5	11	22.0
Hudson River*	1	12	..	1	14	28.0
Unknown	..	1	..	1	2	4.0
Sub-total	1	18	1	7	27	54.0
South of New York						
New Jersey	2	4	..	2	8	16.0
Delaware	3	1	..	1	5	10.0
Maryland	1	1	..	1	3	6.0
Virginia	1	..	..	..	1	2.0
Sub-total	7	6	..	4	17	34.0
Unknown	..	..	1	..	1	2.0
Total						
Number	9	25	5	11	50	100.0
Per cent	18.0	50.0	10.0	22.0	100.0	xxx

* Includes all of New York Harbor.

Beach in 1961. Of these, 33 were recovered, representing a return of 9.9 per cent. A summary of the tagging and recovery data by months is presented in Table 5. Most of the specimens (45.4 per cent) were taken by sport fishing, although 36.4 per cent were taken by the commercial fishery and more than 18 per cent were discovered in a dead or dying condition (Table 6).

An examination of the seasonal and geographic distribution of these recoveries (Table 7) reveals that while recaptures were made from as far north as Maine to as far south as Virginia, more than 75 per cent of the returns came from New York. It should be noted, however, that six of the 25 recoveries from New York were fish that had apparently sustained fatal injuries during tagging. Only two returns (6.1 per cent)

Table 3. Returns for Striped Bass Tagged at Westhampton Beach According to Manner of Recovery

Manner of recovery	Number	Per cent
Sport fishing		
Trolling	4	8.0
Casting	2	4.0
Unknown	10	20.0
Sub-total	16	32.0
Commercial fishing		
Gill net	20	40.0
Haul seine	9	18.0
Pound net	1	2.0
Fyke net	1	2.0
Unknown	3	6.0
Sub-total	34	68.0
Total	50	100.0

were received from New England waters, and only six returns (18.1 per cent) came from the area to the south of New York. Four of the latter were from New Jersey.

Although winter and spring recoveries were few (7) and constituted only about 20 per cent of all tag returns, all winter recoveries were from Delaware Bay to the south of New York (Figure 28), while spring recovery locations were distributed from the mouth of Chesapeake Bay northward to the south shore of Long Island (Figure 29). Nearly all summer and fall recoveries, however, which respectively comprised 33 per cent and 45 per cent of all tag returns, were made at various locations along the south shore of Long Island. Indeed, 10 of 11 summer returns (Figure 30) and 13 of 15 fall returns (Figure 31) came from New York; the others came from Maine, Massachusetts and New Jersey. No tagged fish were recaptured from the Hudson River. Specific recovery locations are listed in Table 8.

Large Fish A total of 580 striped bass 6 pounds or more in weight or 600 millimeters or more in fork length were tagged at Great South Beach during this period: 75 in 1961, 134 in 1962 and 371 in 1963. Of these, 67 specimens (11.6 per cent) were recaptured (Table 9). More than 60 per cent of the recaptured fish were taken by sport fishing (Table 10). The remainder were taken by the commercial fishery (29.8 per cent) or were found dead or dying (7.5 per cent).

Somewhat similar to the geographic distribution of returns for the small striped bass tagged in 1961, that for the large fish tagged from

Figure 24. Winter recovery locations for striped bass tagged at Westhampton Beach from 1954 to 1956.

Figure 25. Spring recovery locations for striped bass tagged at Westhampton Beach from 1954 to 1956.

Figure 26. Summer recovery locations for striped bass tagged at Westhampton Beach from 1954 to 1956.

Figure 27. Fall recovery locations for striped bass tagged at Westhampton Beach from 1954 to 1956.

TABLE 4. SPECIFIC RECOVERY LOCATIONS, BY MONTH, FOR STRIPED BASS TAGGED AT WESTHAMPTON BEACH, 1954–1956

Month	Location	Number	Remarks
January	North Atlantic	1	ocean, offshore
	Maryland		
	Annapolis	1	Chesapeake Bay
February	New Jersey		
	East Point	2	Delaware Bay
	Delaware		
	Little Creek	2	Delaware Bay
	Virginia		
	James River	1	
March	New York		
	Hudson River	1	Ossining
	New York Harbor	1	Liberty Island
	Unknown	1	(Fulton Fish Market)
	New Jersey		
	Tom's River	1	Barnegat Bay
	Delaware		
	Lewes	1	Delaware Bay
	Bowers Beach	1	Delaware Bay
April	New York		
	Hudson River	3	Haverstraw (1), Ossining (2)
	New Jersey		
	Dividing Creek	1	Delaware Bay
May	Massachusetts		
	Swansea	1	Mount Hope Bay
	New York		
	Gardiners Bay (L. I.)	1	
	Southampton (L. I.)	1	
	Westhampton (L. I.)	1	
	Hudson River	7	Nyack (6), Piermont (1)
	New York Harbor	1	Liberty Island
	New Jersey		
	Sandy Hook	1	
	Maryland		
	Manokin River	1	Chesapeake Bay
June	Massachusetts		
	Westport Point	1	Rhode Island Sound
	New York		
	Easthampton (L. I.)	1	
	Southampton (L. I.)	1	
	Jamaica Bay (L. I.)	1	
	New Jersey		
	Seabright	1	
July	Rhode Island		
	Newport	1	Narragansett Bay
	Unknown	1	(postmarked California)
August	Massachusetts		
	Yarmouthport	1	Cape Cod Bay
October	New York		
	New York Harbor	1	Liberty Island
	Unknown	1	(Fulton Fish Market)

Table 4. (*continued*)

Month	Location	Number	Remarks
November	New York		
	Westhampton (L. I.)	2	
	Maryland		
	Manokin River	1	Chesapeake Bay
December	New York		
	Fire Island (L. I.)	3	
	New Jersey		
	Tom's River	1	Barnegat Bay
	Harvey Cedars	1	Barnegat Bay
	Delaware		
	Lewes	1	Delaware Bay

Table 5. Summary of Records for Small* Striped Bass Tagged at Great South Beach, 1961

Month tagged	Number tagged	Recoveries	
		Number	Per cent
June	14	3	21.4
July	36	3§	8.3
August	267	20†	7.5
September	6	3	50.0
October	9	4	44.4
Total	332	33	9.9

* Fish less than 6 pounds or 600 millimeters.
§ One found dying near release site 4 days after tagging.
† Five found dead near release site 2 to 20 days after tagging.

1961 to 1963 extended from Maine to Virginia, but most recoveries (52.2 per cent) were made in New York waters (Table 11). With the exception of one from the Hudson River, all returns from New York represented fish taken along the south shore of Long Island. Of all those recaptured, 14 (20.9 per cent) were taken from New England waters, of which seven were from Massachusetts and four from Rhode Island. A total of 18 returns (26.9 per cent) were received from areas south of New York. Of these, 11 (16.4 per cent) were from New Jersey alone.

Recovery locations are listed by month in Table 12. Only seven recoveries (10.4 per cent) were made during the winter. All of these

TABLE 6. RETURNS FOR SMALL* STRIPED BASS TAGGED AT GREAT SOUTH BEACH ACCORDING TO MANNER OF RECOVERY

Manner of recovery	Number	Per cent
Sport fishing		
Casting	7	21.2
Trolling	4	12.1
Still-fishing	4	12.1
Sub-total	15	45.4
Commercial fishing		
Haul seine	9	27.3
Gill net	3	9.1
Sub-total	12	36.4
Miscellaneous		
Found dead or dying	6	18.2
Total	33	100.0

* Fish less than 6 pounds or 600 millimeters.

TABLE 7. SEASONAL AND GEOGRAPHIC DISTRIBUTION OF RECOVERIES OF SMALL* STRIPED BASS TAGGED AT GREAT SOUTH BEACH, 1961

Location	Season				Total	
	Winter	Spring	Summer	Fall	Number	Per cent
North of New York						
Maine	..	..	1	..	1	3.0
Massachusetts	..	..	..	1	1	3.0
Sub-total	..	..	1	1	2	6.0
New York						
Long Island	..	2	10	13	25	75.8
Sub-total	..	2	10	13	25	75.8
South of New York						
New Jersey	2	1	..	1	4	12.1
Delaware	1	..	..	..	1	3.0
Virginia	..	1	..	..	1	3.0
Sub-total	3	2	..	1	6	18.1
Total						
Number	3	4	11	15	33	100.0
Per cent	9.1	12.1	33.3	45.5	100.0	xxx

* Fish less than 6 pounds or 600 millimeters.

Figure 28. Winter recovery locations for small striped bass tagged at Great South Beach in 1961.

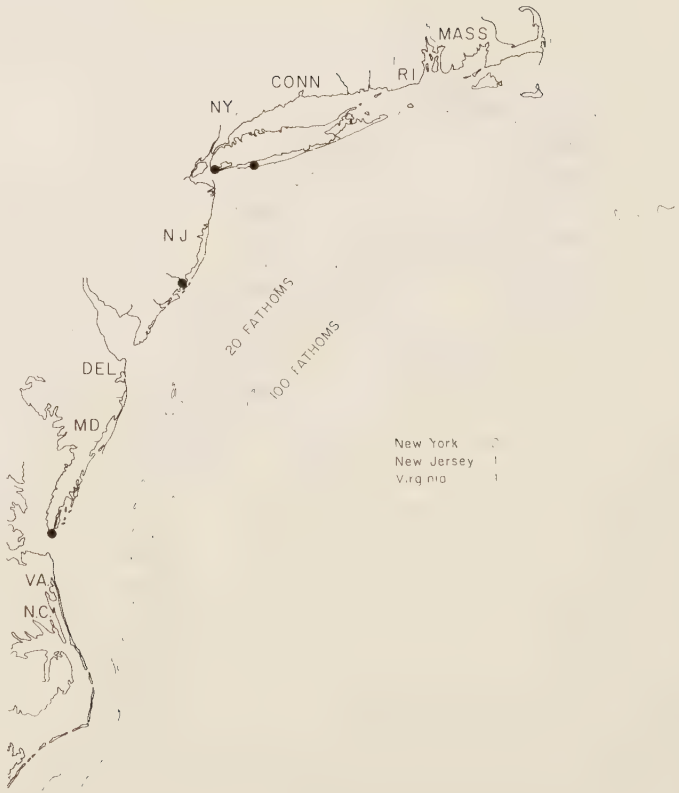

Figure 29. Spring recovery locations for small striped bass tagged at Great South Beach in 1961.

Figure 30. Summer recovery locations for small striped bass tagged at Great South Beach in 1961.

Figure 31. Fall recovery locations for small striped bass tagged at Great South Beach in 1961.

Table 8. Specific Recovery Locations, by Month, for Small* Striped Bass Tagged at Great South Beach, 1961

Month	Location	Number	Remarks
March	New Jersey		
	Reed's Beach	1	Delaware Bay
	Stow Creek Landing	1	Delaware Bay
	Delaware		
	Bowers Beach	1	Delaware Bay
April	New Jersey		
	Graveling Point	1	Great Bay
May	New York		
	Coney Island (L. I.)	1	
	Wantagh Parkway Bridge (L. I.)	1	Jones Beach State Park
	Virginia		
	Kiptopeke	1	Chesapeake Bay
June	New York		
	Smith Point County Park (L. I.)	1	Great South Beach
July	New York		
	East Moriches (L. I.)	1	Moriches Bay
	Mastic Beach (L. I.)	1	Moriches Bay§
August	Maine		
	Stockton Springs	1	Penobscot Bay
	New York		
	Long Cove (L. I.)	1	Great South Beach§
	Smith Point County Park (L. I.)	1	Great South Beach§
	Fair Harbor (L. I.)	1	Great South Beach§
	Moriches Inlet (L. I.)	1	Great South Beach§
September	Massachusetts		
	Cuttyhunk Island	1	Rhode Island Sound
	New York		
	Patchogue River (L. I.)	1	Great South Bay§
	1 mile west of Moriches Inlet (L. I.)	1	Great South Beach§
	Moriches Inlet (L. I.)	1	Great South Beach§
October	New York		
	3 miles west of Moriches Inlet (L. I.)	6	Great South Beach
	Fire Island Inlet (L. I.)	2	Great South Beach
	Smith Point County Park (L. I.)	1	Great South Beach
	Ocean Beach (L. I.)	1	Great South Beach
	Moriches Inlet (L. I.)	1	Great South Beach
	2 miles west of Smith Point County Park	1	Great South Beach
	Captree State Park	1	Great South Bay
November	New Jersey		
	Lavalette	1	

* Fish less than 6 pounds or 600 millimeters.
§ Found dead in water or on beach.

were from waters to the south of New York, four being made in the ocean off of the New Jersey shore (Figure 32). Spring recoveries, how-

TABLE 9. SUMMARY OF RECORDS FOR LARGE* STRIPED BASS TAGGED AT GREAT SOUTH BEACH, 1961–1963

Month tagged	Number tagged	Recoveries	
		Number	Per cent
1961			
June	25	5	20.0
July	13	2	15.4
August	7	2	28.6
September	5	1	20.0
October	22	6	27.3
November	3	0	0.0
Sub-total	75	16	21.3
1962			
May	59	4	6.8
June	17	4	23.5
July	15	3	20.0
August	15	1	6.7
September	7	0	0.0
October	21	3	14.3
Sub-total	134	15	11.2
1963			
May	28	2	7.1
June	140	7§	5.0
July	21	2	9.5
August	26	4	15.4
September	2	0	0.0
October	74	9	12.2
November	80	12†	15.0
Sub-total	371	36	9.7
Total	580	67	11.6

* Fish 6 pounds or 600 millimeters or larger.
§ One found dead near release site 12 days after tagging; one found dying at water surface 35 miles west of release site 12 days after tagging.
† Two washed ashore dead near release site a few hours after tagging.

ever, which totaled 19 and constituted approximately 28 per cent of all returns, were reported from various locations within the area extending from Chesapeake Bay in Virginia to Cape Cod in Massachusetts (Figure 33). Most of the large fish recaptured (28 or 41.8 per cent) were taken during the summer, and most of these (19) came from the south shore

Table 10. Returns for Large* Striped Bass Tagged at Great South Beach According to Manner of Recovery

Manner of recovery	Number	Per cent
Sport fishing		
Casting	22	32.8
Trolling	13	19.4
Still-fishing	5	7.5
Spearing	2	3.0
Sub-total	42	62.7
Commercial fishing		
Haul seine	6	9.0
Gill net	6	9.0
Otter trawl	4	6.0
Pound net	1	1.5
Jacking	1	1.5
Unknown	2	3.0
Sub-total	20	29.8
Miscellaneous		
Found dead or dying	5	7.5
Total	67	100.0

* Fish 6 pounds or 600 millimeters or larger.

of Long Island. With the exception of one (from Maryland), all summer tag returns were from the area from New York northward to Maine (Figure 34). There were 13 tag returns (19.4 per cent) during the fall, 11 from Long Island and 2 from New Jersey (Figure 35).

DISCUSSION

The data gathered relate to a number of topics. These are discussed separately.

Durability of Tags

More than 80 per cent of all the recoveries of fish tagged in the present study occurred within 1 year following release (Table 13). Moreover, except for two fish tagged between 1954 and 1956 at Westhampton Beach, all recoveries were made within 2 years after tagging. All those for fish tagged with Petersen disks between 1954 and 1956 occurred within 317 days of release, while all returns (10) after this time interval were for fish marked with jaw-ring tags. Davis (1959) reported no returns from Petersen disk-tagged striped bass beyond 349 days after release, while Lewis (1961) noted that, of three types of tag (Petersen, streamer and jaw ring) tested on the species in Chesapeake Bay, the

TABLE 11. SEASONAL AND GEOGRAPHIC DISTRIBUTION OF RECOVERIES OF LARGE* STRIPED BASS TAGGED AT GREAT SOUTH BEACH, 1961–1963

Location	Season				Total	
	Winter	Spring	Summer	Fall	Number	Per cent
North of New York						
Maine	..	..	1	..	1	1.5
Massachusetts	..	4	3	..	7	10.4
Rhode Island	..	1	3	..	4	6.0
Connecticut	..	1	1	..	2	3.0
Sub-total	..	6	8	..	14	20.9
New York						
Long Island	..	4	19	11	34	50.7
Hudson River	..	1	..	..	1	1.5
Sub-total	..	5	19	11	35	52.2
South of New York						
New Jersey	4	5	..	2	11	16.4
Delaware	1	..	..	..	1	1.5
Maryland	1	2	1	..	4	6.0
Virginia	1	1	..	..	2	3.0
Sub-total	7	8	1	2	18	26.9
Total						
Number	7	19	28	13	67	100.0
Per cent	10.4	28.4	41.8	19.4	100.0	xxx

* Fish 6 pounds or 600 millimeters or larger.

jaw-ring tag was the one most frequently returned from fish which had been at liberty for more than 450 days. Two fish marked at Westhampton Beach with jaw-ring tags were recovered more than 4 years after tagging. Although the date and location of recapture are doubtful for one of these returns, the other seems quite authentic. The latter was recaptured in a gill net set in the Hudson River near Piermont (N.Y.) on May 3, 1960 after having been at liberty for 1,648 days (4.5 years).

These observations are similar to those of other investigators who have recorded few recoveries from tagged striped bass more than 1 or 2 years after release, especially fish marked entirely or in part with Petersen disks (Clark, 1936; Pearson, 1938; Merriman, 1941; Vladykov and Wallace, 1938, 1952; Morgan and Gerlach, 1950; Calhoun, 1952; Raney *et al.*, 1954; Mansueti, 1961; Massmann and Pacheco, 1961). Several authors have suggested that the low incidence of tag recoveries from striped bass that have been at liberty more than 2 years can be attrib-

Table 12. Specific Recovery Locations, by Month, for Large* Striped Bass Tagged at Great South Beach, 1961–1963

Month	Location	Number	Remarks
January...	New Jersey		
	Barnegat Inlet	1	ocean, 1 mile offshore
	Harvey Cedars	1	ocean, 5 miles offshore
	Delaware		
	Mispillion River Light	1	Delaware Bay
	Maryland		
	Assawoman Bay	1	
	Virginia		
	Great Machiponga Channel	1	§
February..	New Jersey		
	Brigantine	1	ocean, 3 miles offshore
April.....	New Jersey		
	Seaside Park	1	
	Island Beach State Park	1	
	Maryland		
	Poole Island	1	Chesapeake Bay
	Potomac River	1	Chesapeake Bay
	Virginia		
	Mobjack Bay	1	Chesapeake Bay
May.....	Massachusetts		
	Rock Harbor	1	Cape Cod Bay
	Nauset Beach	1	Cape Cod
	Cotuit	1	Cape Cod
	Connecticut		
	Connecticut River	1	Long Island Sound
	New York		
	Jones Inlet (L. I.)	1	Jones Beach State Park
	Rockaway Inlet (L. I.)	1	
	Moriches Bay (L. I.)	1	
	Hudson River	1	Kingston
	Unknown	1	(Fulton Fish Market)
	New Jersey		
	Maurice River	1	Delaware Bay
	Plum Island	1	Sandy Hook Bay
June.....	Massachusetts		
	Billingsgate Island	1	Cape Cod Bay
	Bourne	1	Cape Cod Canal
	Rhode Island		
	Patience Island	1	Narragansett Bay
	Newport	1	Narragansett Bay
	New York		
	Point Lookout (L. I.)	1	Jones Inlet
	Jones Beach State Park (L. I.)	1	ocean ½ mile offshore §
	Great South Beach (L. I.)	1	1 mile west of Moriches Inlet §
	New Jersey		
	Barnegat Inlet	1	
July.....	Maine	1	
	Kennebunk		Mousum River
	Massachusetts	1	
	Cuttyhunk Island	1	Rhode Island Sound
	Mashpee River		Cape Cod
	Connecticut	1	
	Stonington		

TABLE 12. (*continued*)

Month	Location	Number	Remarks
	New York		
	Jones Beach State Park (L. I.)	1	
	Montauk Point (L. I.)	1	
	Long Beach (L. I.)	1	
	Southampton (L. I.)	1	
	Wantagh (L. I.)	1	Goose Creek Channel
	Speonk Point (L. I.)	1	Moriches Bay
	Maryland		
	Nanticoke River	1	Chesapeake Bay
August	Rhode Island		
	Newport	1	Narragansett Bay
	New York		
	Montauk (L. I.)	3	
	Jones Inlet (L. I.)	2	Jones Beach State Park
	Amagansett (L. I.)	1	
	Hampton Bays (L. I.)	1	
	Atlantic Beach (L. I.)	1	
September	Rhode Island		
	Newport	1	Narragansett Bay
	New York		
	Moriches Inlet (L. I.)	1	
	Lido Beach (L. I.)	1	
October	New York		
	Oak Beach (L. I.)	1	Fire Island Inlet
	Remsenburg (L. I.)	2	Moriches Bay
	Wantagh (L. I.)	1	Goose Creek Channel
	Smith Point County Park (L. I.)	1	Great South Beach
	3 miles west Moriches Inlet (L. I.)	1	Great South Beach
November	New York		
	Montauk (L. I.)	1	
	Rockaway Inlet (L. I.)	1	
	3 miles west Moriches Inlet (L. I.)	2	Great South Beach §
	Long Island	1	(specific location unknown)
	New Jersey		
	Beach Haven	1	ocean, offshore
December	New Jersey		
	Seaside Park	1	ocean, 4 miles offshore
	Barnegat Inlet	1	ocean, 1 mile offshore

* Fish 6 pounds or 600 millimeters or larger.
§ Found dead or dying in water or on beach.

uted primarily to detachment or "shedding" of the Petersen tag (Pearson, 1938; Wallace and Neville, 1942; Raney, 1952; Chadwick, 1963), while others have presented evidence to support this hypothesis through both field and laboratory experiments (Calhoun *et al.*, 1951; Calhoun, 1953; Skinner and Calhoun, 1954; Davis, 1959; Lewis, 1961). On the other hand, that striped bass can retain the Petersen tag for a considerable

Figure 32. Winter recovery locations for large striped bass tagged at Great South Beach from 1961 to 1963.

Figure 33. Spring recovery locations for large striped bass tagged at Great South Beach from 1961 to 1963.

Figure 34. Summer recovery locations for large striped bass tagged at Great South Beach from 1961 to 1963.

Figure 35. Fall recovery locations for large striped bass tagged at Great South Beach from 1961 to 1963.

Table 13. Frequency Distributions of Recoveries According to Number of Days at Liberty for Striped Bass Tagged at Westhampton Beach from 1954 to 1956 and at Great South Beach from 1961 to 1963

Days at liberty	Recoveries	
	Number	Per cent
Westhampton Beach		
0– 365	41	82.0
366– 730	7	14.0
731–1,095	0	0.0
1,096–1,460	0	0.0
1,461–1,825	2†	4.0
Total	50	100.0
Great South Beach, 1961*		
0– 365	31	93.9
366– 730	2	6.1
Total	33	100.0
Great South Beach, 1961–1963§		
0– 365	57	85.1
366– 730	10	14.9
Total	67	100.0

* Fish less than 6 pounds or 600 millimeters.
§ Fish 6 pounds or 600 millimeters or larger.
† One of doubtful date and location.

length of time has been observed by both Vladykov and Wallace (1952) and Skinner and Calhoun (1954), who reported recoveries for specimens bearing this tag that had been at liberty for periods of 3 years and 3 months, and 2 years and 9 months, respectively. Alperin (1966) reported returns for striped bass tagged with vinyl "spaghetti" tubing and dangler in Great South Bay as long as 4 years (1,462 days) after release.

Influence and Origin of the 1958 and 1961 Year Classes

The monthly and annual age-frequency distributions of all specimens collected at Great South Beach from 1961 to 1963 reveal that the striped bass population was dominated at the time by fish from the 1958 and 1961 year classes. More than half the fish recorded in 1962 were 4 years olds, while 2-year-old and 5-year-old specimens together constituted nearly 75 per cent of the catch in 1963 (Figures 9 to 11). More-

over, since all specimens captured in July of 1961 and all but a few collected in August of the same year were tagged, the age-composition data for these fish are also representative of the total catches during those months (Figure 16); these data indicate that nearly 50 per cent of the July catch and 85 per cent of the August catch were comprised of 3-year-old fish.

Raney (1952), in his review of the life history of the striped bass, noted that this fish is one species "subject to the so-called 'dominant year-class' phenomenon" whereby from time to time a large number of offspring are produced and survive from a not necessarily large spawning population. The 1958 year class was a very dominant one, and its influence on the Atlantic coastal population of striped bass has been reported by several authors. Shearer *et al.* (1962), Frisbie and Ritchie (1963) and Mansueti and Hollis (1963), for example, observed a greatly increased catch rate for striped bass in the sport fishery of Chesapeake Bay during 1960 and attributed the "excellent" fishing to the abundance of the dominant 1958 year class. Similarly, Briggs (1962, 1965) also arrived at the same conclusion as an explanation, in part at least, for the increased catch and catch rate for striped bass in several of the sport fisheries along the south shore of Long Island between 1960 and 1963. Moreover, Alperin (1966) conjectured that it was the 1958 year class which comprised the major portion of striped bass collected and tagged in Great South Bay during 1960 and 1961. While both the latter authors based their assumptions largely on the sizes of fish in the catch, the results of the present study would seem to substantiate them since ages were determined from actual counts of scale annuli.

Because of the obvious importance of the dominant 1958 and, to a lesser degree, 1961 year classes to the striped bass population in Long Island waters, it is of considerable interest to speculate on their origin. It has been demonstrated from past tagging studies (Vladykov and Wallace, 1938, 1952; Chapoton and Sykes, 1961; Mansueti, 1961; Massmann and Pacheco, 1961; Nichols and Miller, 1967) that at least a small percentage of striped bass 2 years of age and older migrate out of Chesapeake Bay and northward along the Atlantic coast. While small, this percentage led Nichols and Miller to conclude that "the Potomac River is a significant contributor to the striped bass stocks along the northeast Atlantic coast". Moreover, certain investigators (Merriman, 1937, 1941; Vladykov and Wallace, 1938, 1952; Neville *et al.*, 1939; Neville 1940; Wallace and Neville, 1942; Tiller, 1950) have observed the strong influence of dominant year classes on stocks of striped bass in northern waters (primarily New York and southern New England) 2 and more years following good production of young-of-the-year fish in Chesapeake Bay. Based on the evidence at hand, a similar relationship

is indicated for the 1958 and 1961 year classes. Mansueti and Hollis (1963), for example, stated that "exceptionally good striped bass production from spawning was found in 1950, 1954, 1956, 1958, 1961 and 1962" in Chesapeake Bay. This statement, when related to the subsequent observations of Shearer *et al.* (1962), Frisbie and Ritchie (1963), Briggs (1962, 1965) and Alperin (1966) and the results of the present study, seem to suggest strongly that Chesapeake Bay was the major geographical source of the 1958 and 1961 year classes. Similarly, both Briggs and Alperin concluded that Chesapeake Bay was the most probable major location from which the 1958 year class originated.

Contribution of the Hudson River

The geographical distribution of tag recoveries by season from all fish tagged during the present study suggests an annual migratory pattern highly reminiscent of that already well documented for the Atlantic coast of the United States (Vladykov and Wallace, 1938, 1952; Merriman, 1937, 1941; Wallace and Neville, 1942; Raney, 1952; Raney *et al.*, 1954). A general northward movement in the spring from southern wintering areas and an opposite return movement in the fall are indicated. The data demonstrate that major wintering areas extended from Virginia to New Jersey as evidenced by the fact that 17 of 19 winter tag returns were received from these states. Of the remaining two winter recoveries, one was taken in New York Harbor and the other somewhere offshore in the North Atlantic. More specifically, the data for tag returns reveal that Delaware Bay and the ocean between 1 and 5 miles offshore along the southern New Jersey coast were probably the most "important" wintering grounds, since nine and four, respectively, of the 17 winter recoveries from south of New York came from these localities. Only two winter returns came from Chesapeake Bay.

The extensive distribution (Virginia to Massachusetts) of the tag recoveries made during the spring suggests that with the onset of this season striped bass vacated the southern wintering areas and began a general coastal movement to the north. It is apparent, however, that the northward migration was essentially completed by summer, since only one of a total of 44 tag recoveries during this season occurred south (Maryland) of the area extending from New York north to Maine. Moreover, a general southward migration in the fall can be conjectured from the locations of the recoveries made during this season; only one of 39 tagged fish was retaken north (Massachusetts) of the area extending from New York south to Maryland.

While such a general migratory pattern can be inferred from the combined recovery data, obvious dissimilarities are also evident when the data for the individual tagging operations (i.e., 1954-1956 and 1961, small specimens; 1961-1963, large specimens) are considered separately.

The number of recoveries from the Hudson River for fish tagged during the 1954-1956 period, for example, is striking when compared with that from the same location for fish tagged between 1961 and 1963. For fish tagged during the earlier period 14 (28.0 per cent) of the 50 recoveries came from the Hudson River, but only one (1.0 per cent) of the 100 recoveries for both small and large fish tagged during the later period came from this stream. A t test indicated a highly significant difference (.01 probability level) between the two proportions ($t = 100$, d.f. $= 148$). Of the 14 Hudson River returns for fish tagged during the 1954-1956 period, 12 represented spring recoveries of which 11 were taken by commercial gill netting in the Haverstraw-Nyack area and one was caught by a sport fisherman on hook and line in New York Harbor. Each of the other two was made by hook and line in New York Harbor, one in the early fall (October 7) and the other in late winter (March 6).

Despite the general absence of winter recoveries from the Hudson River for fish tagged at Westhampton Beach between 1954 and 1956, it seems highly probable from the observations of earlier investigators (Neville, 1940; Vladykov and Wallace, 1952; Raney, 1952; Raney *et al.*, 1954) that the striped bass recaptured in the Hudson River during the spring also overwintered there, in the vicinity of New York Harbor, or in adjacent ocean areas. Assuming this to be true, the paucity of winter recoveries from the Hudson River should not appear surprising because commercial fishing for striped bass is prohibited in the river between the southern end of Manhattan Island and the dam at Troy from December 1 to March 15. At the same time, while not prohibited, sport fishing is greatly reduced because of generally cold and inclement weather conditions.

On the basis of two of 31 recoveries outside Chesapeake Bay, Vladykov and Wallace (1952) concluded that the Hudson River might possibly be a wintering ground for some migrants from Chesapeake Bay. Similarly, Raney (1952) suggested that certain groups of the main migratory body of striped bass defect during the southward fall movement and enter coastal estuaries and rivers such as the Hudson where they spend the winter. In a later study concerning the Hudson River stock, Raney *et al.* (1954) further concluded that striped bass which move out of the Hudson in late spring and summer along both the north and south shores of Long Island, reverse direction in the fall and re-enter the river. This pattern is similar to that hypothesized by Neville (1940).

It is also possible that more of the striped bass of all sizes that were tagged at Great South Beach between 1961 and 1963 overwintered in the Hudson River and may have participated in the spring spawning known to occur there (Curran and Ries, 1937; Greeley, 1937; Neville, 1940; Raney, 1952; Raney *et al.*, 1954; Rathjen and Miller, 1957) than is

Table 14. Selected Data on Commercial Fishing Effort and Catch for Striped Bass in Hudson River, 1955–1965*

Year	Total catch in pounds	Number of special gill nets§	Number of special stake gill nets	
			Entire river	Westchester and Rockland Counties
1955	73,400	184	†	91
1956	92,800	184	†	†
1957	84,500	174	†	†
1958	77,100	167	87	†
1959	133,100	170	97	†
1960	132,900	152	96	58
1961	70,700	144	88	57
1962	48,100	125	74	52
1963	46,700	101	58	37
1964	29,500	†	†	30
1965	36,700	†	†	†

* From southern end of Manhattan Island to Troy; source of data, New York State Conservation Department annual reports from 1956 to 1964 and personal communication from Churchill Smith.
§ Includes both stake and drift gill nets; operated only from March 15 to June 1.
† No data available.

suggested by the tag returns. Indeed, it seems even less likely than before that many of these fish would have been captured even if present in the river during winter or spring, because the commercial fishing effort for the species and the number caught have declined sharply over the last several years, especially between 1962 and 1965 (Table 14). Effort was mainly reflected by the number of special stake gill nets operated in Rockland and Westchester Counties between March 15 and June 1.[3]

On the other hand, although it seems much less likely, it is further possible that the striped bass recaptured in the Hudson River during the spring may have moved there immediately after an extensive early northward migration from southern wintering grounds (e.g., Chesapeake Bay and Delaware Bay). Merriman (1941), for example, reported that one fish tagged in North Carolina "on November 15, 1937, was caught in New Jersey on January 16, 1938, showing that some fish migrate north before the spring months". Moreover, Vladykov and Wallace (1952) indicated that, of 31 recoveries made from outside Chesapeake Bay for fish tagged there during October of 1936 and 1937 and in Croatan Sound (N.C.) during November of 1937, one specimen was recaptured after only 67 days at liberty (December 18) in New York Harbor near Bayonne, New Jersey. Two additional recoveries were made in New Jersey during the following winter (February 1 and 25) after being free

[3] Churchill Smith, personal communication.

for only 110 and 122 days, while 16 fish were recaptured in coastal areas from Maryland to Massachusetts during the subsequent spring (March 22 to June 14). Similarly, in a more recent publication, Nichols and Miller (1967) noted that, of 43 striped bass tagged in the Potomac River during the winter (November through March) and subsequently recovered outside Chesapeake Bay, 26 were recaptured within 117 days from coastal waters as far north as Maine. Of these, one was caught in southern New Jersey (Great Egg Harbor) during March after only 8 days at liberty, and a second was recovered from New York Harbor in April after only 17 days. These latter recoveries seem to further suggest some northward movement in winter and early spring.

The results of the tagging conducted in the present study, however, roughly parallel those presented by Alperin (1966) for striped bass tagged in Great South Bay between 1956 and 1961. He reported that 16.6 per cent and 18.1 per cent, respectively, of the recoveries for fish tagged during 1956 and 1959 came from the Hudson River, but that only 2.0 per cent of those for fish tagged during 1960 and 1961 came from that location. These observations prompted him to hypothesize that "the fish marked in 1956 and 1959 were of more local nature and may have originated in the Hudson River, while those bass marked in 1960 and 1961, which appeared in great numbers, probably originated elsewhere. In the years when migrants from the south are not abundant in Great South Bay, fish of Hudson River origin may be the principal source of supply". Although it may seem contradictory that both Raney *et al.* (1954) and Alperin (1966) suggested that striped bass of Hudson River stock seldom go farther east along the south shore of Long Island than Jones Beach, it should be noted that this conclusion is based solely on recovery data from fish tagged in the Hudson River which were mostly specimens of sublegal (less than 16 inches in fork length) size. It has been demonstrated by several investigators (Vladykov and Wallace, 1938, 1952; Merriman, 1941; Raney, 1952, 1957; Mansueti, 1961; Massmann and Pacheco, 1961; Nichols and Miller, 1967) that small striped bass, especially those less than 2 years old, are, for the most part, nonmigratory. With this in mind, the hypothesis of Alperin (1966) concerning the origins of the Great South Bay population seems quite plausible. Applying similar reasoning to the recovery observations of the present study, it is suggested that a rather sizeable portion of the fish tagged at Westhampton Beach between 1954 and 1956, and possibly some of those tagged at Great South Beach between 1961 and 1963, may have been of Hudson River origin. As indicated earlier, however, most striped bass tagged between 1961 and 1963 at Great South Beach were probably of Chesapeake Bay or Delaware Bay stock.

Migratory Behavior of Large Fish

While the emphasis of the present study was to describe the migra-

tory behavior of large striped bass tagged in Long Island waters, few differences were noted between the distribution of recoveries for small fish tagged in 1961 and large fish tagged between 1961 and 1963 at Great South Beach. Recaptures for both groups were made from Maine to Virginia, although the percentage from waters outside New York was greater for the large fish. These observations suggest that both size groups, especially the larger specimens, were highly migratory. Chapoton and Sykes (1961) noted from tag recovery data that large striped bass, which were marked during the winter on the North Carolina coast, were subsequently recaptured in Chesapeake Bay during the spawning season (spring) and north along the Atlantic coast to New England after the spawning season. While no tags were returned from North Carolina for large fish marked during the present study, there is some evidence from winter recoveries in the coastal areas of Delaware, Maryland and Virginia and spring recoveries in Chesapeake Bay that the large specimens tagged at Great South Beach were of essentially the same stock as those marked by Chapoton and Sykes (1961) in North Carolina. The complete migratory cycle suggested by the latter authors for large striped bass along the Atlantic coast, i.e., North Carolina to New England in the spring with a return movement in the fall, seems to be supported by the results of the present investigation.

Because the striped bass is generally considered to be an inhabitant of "inshore" waters, it is of particular interest to note the number of tag returns for large specimens recaptured between ½ and 5 miles offshore in the ocean. Eight (11.9 per cent) of the 67 recoveries for large fish were taken from this environment, while only one of the small striped bass tagged at Westhampton Beach between 1954 and 1956 and one of the small individuals tagged at Great South Beach in 1961 were recaptured from this habitat (Table 15). Tests of these differences in the proportion of tag returns from offshore waters revealed that the number of recoveries for large fish was significantly higher (.01 probability level) than that for small specimens for bass tagged at either Westhampton Beach ($t = 40.0$, d.f. = 115) or at Great South Beach ($t = 46.2$, d.f. = 98). From these observations, it would appear that the large striped bass tagged during the present study possessed a greater affinity for the oceanic habitat than the smaller specimens. Moreover, six of the eight oceanic recoveries of large fish were made 1 to 5 miles offshore along the coast of southern New Jersey (Seaside Park to Brigantine) between late November and early February during the years 1962 to 1965, while none was recaptured from the inshore waters of New Jersey during the same time period. This further suggests that the ocean area immediately off the coast of southern New Jersey served as an important wintering ground for large striped bass tagged during the present investigation.

TABLE 15. FREQUENCY DISTRIBUTIONS OF RECOVERIES ACCORDING TO RECOVERY ENVIRONMENT FOR STRIPED BASS TAGGED AT WESTHAMPTON BEACH FROM 1954 TO 1956 AND AT GREAT SOUTH BEACH FROM 1961 TO 1963

Recovery environment	Recoveries	
	Number	Per cent
Westhampton Beach		
Ocean, offshore ½ mile or more	1	2.0
Surf and/or inlets	11	22.0
Estuaries and/or rivers	35	70.0
Unknown	3	6.0
Total	50	100.0
Great South Beach, 1961*		
Ocean, offshore ½ mile or more	0	0.0
Surf and/or inlets	20	60.6
Estuaries and/or rivers	13	39.4
Total	33	100.0
Great South Beach, 1961–1963§		
Ocean, offshore ½ mile or more	8	11.9
Surf and/or inlets	31	46.3
Estuaries and/or rivers	26	38.8
Unknown	2	3.0
Total	67	100.0

* Fish less than 6 pounds or 600 millimeters.
§ Fish 6 pounds or 600 millimeters or larger.

IMPORTANCE OF THE SPORT FISHERY

At the time he wrote, Raney (1952) reported that, while catch statistics for the commercial fishery were available, there were no reliable figures for catch of striped bass by the sport fishery along the Atlantic coast of the United States. Although the evidence is sketchy, some data are available which suggest that until recently most of the striped bass harvested along the east coast were landed by commercial fishermen. Vladykov and Wallace (1952), for example, reported that, of 24 striped bass tagged in 1936 and 1937 and recovered by known methods outside Chesapeake Bay between 1937 and 1939, only four (16.7 per cent) were taken on hook and line. It is interesting that many of the states in which these recoveries were made have since enacted legislation prohibiting commercial netting of the species and/or establishing a minimum size

retention limit. Moreover, while no specific data are presented, Merriman (1941) indicated that large quantities of striped bass tagged in Connecticut and Long Island waters in the late 1930's were recaptured by pound nets and haul seines. These types of gear, especially those operated in the ocean, have sharply declined in number during recent times for apparently economic reasons.

The data presented in Tables 3, 6 and 10 indicate that sport fishing accounted for a substantially greater percentage of the recoveries for striped bass of all sizes tagged between 1961 and 1963 at Great South Beach than it did for those tagged at Westhampton Beach between 1954 and 1956. While only 32 per cent of the recoveries from fish tagged at Westhampton Beach were harvested by sport fishing, 45 per cent of the small specimens and more than 60 per cent of the large specimens tagged at Great South Beach were taken in this manner. Moreover, Alperin (1966) reported that nearly 65 per cent of the striped bass tagged in Great South Bay between 1956 and 1961 were recovered by sport fishing, while Chapoton and Sykes (1961) indicated that returns for large fish tagged in North Carolina and recovered north of Chesapeake Bay subsequent to the spawning season were taken by sport fishermen. These observations suggest that sport fishing, which has grown enormously in recent years, is rapidly supplanting commercial fishing as the major method of harvesting striped bass along the Atlantic coast north of Chesapeake Bay. This conclusion is further supported by Clark (1960) who estimated that 9,272,000 striped bass having an aggregate weight in excess of 37,000,000 pounds were landed by salt-water sport fishermen during 1960 in that Atlantic coastal region extending from Maine to Cape Hatteras, North Carolina. During the same year, the striped bass landings for the commercial fisheries from Maine to North Carolina were only 8,550,000 pounds[4], or approximately one-fourth the estimated sport catch. Moreover, for all of Chesapeake Bay during 1962, Elser (1965) estimated that 9,340,000 pounds (approximately 5,000,000 specimens) were harvested by the sport fishery while, for the same area and year, the commercial fishery landed only 3,910,000 pounds or less than half the sport catch. That sport fishing will have an even greater impact on the harvest of striped bass in the future is suggested by the fact that the number of salt-water anglers on the Atlantic coast has expanded from 3,383,000 in 1960 to 4,178,000 in 1965, an increase of nearly 25 per cent over the 5-year period[5].

Since the majority of striped bass tagged during the present investigation were recovered from New York, it is of interest to note the growth of marine sport fishing in this State in recent years and to project this

[4] Source: Fishery Statistics of the United States, 1960. U.S. Dept. Interior.
[5] Source: National Survey of Hunting and Fishing, 1960, U.S. Dept. Interior.

growth into the near future. Based on an average annual rate of increase of 6.7 per cent (Stroud, 1963) and census data compiled by Crossley, S-D Surveys, Inc. (1956), Alperin (1966) estimated that the number of salt-water anglers in New York nearly doubled (from 608,000 to 1,163,000) over the 10-year period between 1955 and 1956. Using the same data to extrapolate further, it is estimated that by 1970 the total number of salt-water anglers in New York will be more than 1,500,000.

CONCLUSIONS

It would appear that, for the most part, the abundance of striped bass inhabiting the south shore surf areas of Long Island is directly dependent upon the contribution of stocks produced in more southern waters, most probably Chesapeake Bay. Apparently only in years when this contribution is low does the influence of Hudson River stock on the south shore population become evident. It should further be noted that, from the best information available, the annual production in Chesapeake Bay is primarily governed by environmental conditions over which man has little control. Indeed, Mansueti and Hollis (1963) concluded that "under most conditions, the effects of environment determine the success or failure of a hatch, and man's fishing at the present intensity seems to have little effect on the long-range production of striped bass in Chesapeake Bay. The most essential long-range management measure to insure high spawning success is the protection, maintenance and in some case rehabilitation of the favorable environmental conditions on the important breeding and nursery areas".

It seems extremely doubtful that New York fishermen have any measurable influence on the abundance of striped bass which occur seasonally along Long Island's south shore. It also appears that effective management must be centered largely at the geographical source of the stocks. At present, Chesapeake Bay fishermen are permitted to catch and retain striped bass having a total length of 12 inches, a size which is considered to be marketable. Quite naturally, this regulation is designed to benefit Chesapeake Bay fishermen primarily. Since it has been demonstrated by many investigators that very few striped bass 12 inches long or smaller (mostly 2 years old or younger) migrate out of Chesapeake Bay, there is little risk of loss (except through natural mortality) involved for Chesapeake fishermen in waiting 2 years before harvesting any particular year's brood production. Moreover, when legal size is attained, exploitation is intense. For only the spring months, the rate of harvest has been estimated to be a high as 45 per cent for the commercial fishery alone on fish ranging from 2 to 4 years of age (Mansueti and Hollis, 1963). Additional intense exploitation by the sport fishery, which probably equals or even exceeds that of the commercial fishery, occurs

after the spring period (Shearer *et al.*, 1962; Frisbie and Ritchie, 1963; Mansueti and Hollis, 1963; Elser, 1965). Presumably, it is but a small segment of those that survive this exploitation which move out of Chesapeake Bay and migrate northward where they comprise the bulk of the coastal striped bass population. Mansueti and Hollis (1963) concluded that "at this time, the best information suggests that Maryland anglers and netters would probably lose and fishermen in other Atlantic seaboard states would gain benefits if the minimum size limit were raised to 16 inches".

It is interesting then that all of the northern states from New Jersey to Maine, none of which is an important source of the migratory stock or stands to benefit from the 12-inch minimum size limit in Chesapeake Bay, should further attempt to manage the resource through regulations such as a size limit of 16 inches in fork length (about 18 inches in total length) or the prohibition of netting. Some states, e.g., Maine and New Jersey, have even established a daily catch limit and a fishing season. While it is true that the 16-inch size limit permits the fish a period of maximum rate of growth in length and weight before being subject to capture, it seems doubtful that this regulation affects the size of the coastal migratory population one way or another. Poole (1965) concluded that "since the catch relationships and source of the migratory stock are such as they are, the existing 16-inch and 18-inch size limits and laws prohibiting netting in the Middle Atlantic and New England States do not appear to be of any benefit to the striped bass population, and it is quite evident that further restrictions in these states will have little or no effect on the abundance of the fish". New York's 16-inch size limit offered protection for less than 12 per cent of the bass seined each year at Great South Beach during the present study (Figures 8 and 21).

Therefore, since it seems clear that fishing regulations in New York have little effect on the size of the coastal migratory population of striped bass, unrestricted fishing for the fish that occur seasonly along Long Island's south shore might be warranted. In this way, full advantage could be taken of the dominant year classes that occur periodically in Chesapeake Bay. On the other hand, New York might well give more attention to that segment of the striped bass population over which it may have some control, i.e., the stock which originates in the Hudson River. Because environment may play a vital role in striped bass production, perhaps habitat protection in this river would be the single most important contribution that New York could make toward enhancing the striped bass resource of the Atlantic coast. While it has been demonstrated by this and other studies that, during certain years at least, striped bass of probable Hudson River origin make some contribution to Long

Island and other coastal waters, the actual measure of this contribution remains a question which can be answered only through additional research.

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DISTRIBUTION AND MORTALITY OF REDHEADS BANDED IN NEW YORK[1]

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ABSTRACT

Redheads that winter in New York constitute less than 1 per cent of the continental population but afford important diving duck hunting in the State. Records for 10,388 birds banded in central New York during the winters of 1955 to 1960 provided information on distribution and mortality. Average first-year recoveries showed that 47 per cent were harvested north and west of New York, 24 per cent in New York, 26 per cent south and east of New York and a scattering elsewhere in the country. Data for individual years varied markedly. First-year recovery rates for the hunting seasons from 1955-56 through 1958-59 ranged from 7.0 to 8.7 per cent. Reduction of the bag limit in 1958-59 did not reduce the recovery rate because the lateness of the second half of the split season selected in New York resulted in more productive hunting. The recovery rates in 1959-60 and 1960-61 were limited both by bag restrictions and by the time of the open season. The data suggest that terminating the open season prior to late December would reduce the harvest of redheads only slightly while reducing that of canvasbacks substantially. The sex ratio for all birds averaged 78.5 males to 21.5 females, and a sample of first-year birds showed 75.8 males to 24.2 females. The proportion observed during aerial surveys was similar. Mortality rates for females during their first year, and usually their second year, were higher than those for males although the total rates were about equal. Evidence indicates that a high harvest of females occurs before the birds reach New York and that males predominate among both juveniles and adults throughout the fall. In New York, adult females were found to be 1.38 times as vulnerable to gunning as adult males. There is need for hunting regulations that would reduce the disproportionate loss of females.

On a continental basis, the number of redheads (*Aythya americana*) that winter in New York seems insignificant. Weller (1964), in discussing the distribution and migration of the species, suggested that those that winter in this state constitute only a fraction of 1 per cent of the continental population. Nevertheless, New York waterfowlers rate the redhead along with the canvasback (*Aythya vallisneria*) and the two scaups (*Aythya marila* and *A. affinis*) as important contributors to diving duck hunting. Some 5,000 to 15,000 redheads winter in the Finger Lakes region. Many thousands more migrate through the State to join the wintering population in the area from Chesapeake Bay to Pamlico Sound which Weller (1964) estimated as 11.9 per cent of the continental population.

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The first bandings of redheads in New York were made in the early 1920's by Dr. A. A. Allen (Schierbaum *et al.*, 1959), but less than 1,000 were banded in the State prior to 1955. From 1955 through 1960 State personnel and cooperating sportsmens' organizations banded 10,388 redheads during January, February and March (Table 1). This paper is based on these bandings. Redheads banded elsewhere but recovered in New York are referred to when they supply useful information. However, some records for birds banded during the years 1961 to 1964 are used to assess sex ratios and rates of retrapping.

Following the practice of the U.S. Fish and Wildlife Service, all winter-banded birds taken after January 1 are considered adults since one leg of their annual migration has been completed. Many birds of the year were banded, but no accurate measure of the ratio of young to

Table 1. Redheads Trapped and Banded in New York from 1955 to 1960 during January, February and March

Year	Sex	Cayuga Lake	Seneca Lake	Canandaigua Lake	Dunkirk Harbor	Total	Sex ratio
1955.....	Male	17	255	347	85	704	78
	Female	4	78	102	17	201	22
	Total	21	333	449	102	905	xxx
1956.....	Male	36	972	1,283	258	2,549	76
	Female	20	341	325	141	827	24
	Total	56	1,313	1,608	399	3,376	xxx
1957.....	Male	3	333	338	184	858	71
	Female	..	130	161	52	343	29
	Total	3	463	499	236	1,201	xxx
1958.....	Male	7	233	571	76	887	78
	Female	3	38	176	29	246	22
	Total	10	271	747	105	1,133	xxx
1959.....	Male	..	545	928	47	1,520	83
	Female	..	110	172	21	303	17
	Total	..	655	1,100	68	1,823	xxx
1960.....	Male	..	481	1,160	..	1,641	84
	Female	..	113	196	..	309	16
	Total	..	594	1,356	..	1,950	xxx
Total.....	Male	63	2,819	4,627	650	8,159	78.5
	Female	27	810	1,132	260	2,229	21.5
	Total	90	3,629	5,759	910	10,388	xxx

adults could be made. Cloacal examination showed that young were taking on characteristics of adults during the months of trapping. Recoveries during the first hunting season for winter-banded birds are termed indirect returns because the birds have migrated north and gone through a breeding season before being subject to gunning.

No special effort was made to take one species of diving duck over another at the banding stations. The type of trap used, with minor

Table 2. Distribution of First-year Recoveries by Hunting for Redheads Banded in New York from 1955–56 to 1960–61

Recovery location	Year recovered						Total	
	1955–56	1956–57	1957–58	1958–59	1959–60	1960–61	Number	Per cent
Breeding range								
Alberta	..	..	..	1	..	1	2	0.4
Saskatchewan	..	2	2	..	..	..	4	0.7
Manitoba	2	14	3	1	4	1	25	4.4
North Dakota	..	6	4	1	1	..	12	2.1
South Dakota	1	2	5	1	..	..	9	1.6
Minnesota	6	18	13	6	15	..	58	10.1
Migration route to Atlantic Flyway								
Wisconsin	5	6	6	3	2	1	23	4.1
Illinois	..	1	..	1	..	..	2	0.4
Michigan	10	27	17	14	12	..	80	14.0
Ontario	8	17	13	7	9	..	54	9.5
Ohio	..	..	1	..	..	..	1	0.2
New York	32	46	16	39	3	1	137	24.1
New Jersey	1	1	1	1	..	..	4	0.7
Pennsylvania	1	3	..	1	..	..	5	0.9
Maryland	12	74	15	14	4	..	119	20.9
Virginia	..	7	1	1	..	..	9	1.6
Massachusetts	..	..	..	1	..	..	1	0.2
Rhode Island	..	1	..	..	..	..	1	0.2
North Carolina	1	5	1	1	..	..	8	1.4
Florida	..	1	..	..	..	..	1	0.2
Other								
Wyoming	..	..	..	..	1	..	1	0.2
Kansas	..	..	2	..	..	..	2	0.4
Missouri	..	..	..	1	..	..	1	0.2
Kentucky	..	2	..	..	..	..	2	0.4
Louisiana	..	3	..	..	..	..	3	0.5
Texas	..	1	1	..	..	..	2	0.4
California	..	1	..	..	..	..	1	0.2
Total	79	238	101	94	51	4	567	100.0

individual variations, was that described by Schierbaum and Talmadge (1954). During the 6-year period 10,388 redheads and 10,553 canvasbacks were banded, but the relative numbers varied from year to year. In 1956 there were 3,376 redheads and 1,953 canvasbacks trapped. In 1957 the positions were reversed, i.e., 1,201 redheads and 3,697 canvasbacks. These differences related roughly to the numbers of birds present.

BREEDING AND WINTER RANGES

The distribution of recoveries for these winter-banded birds (Table 2) is one source of information on their breeding areas. These data suggest that Manitoba, Minnesota and the Dakotas were the breeding grounds that contributed the most redheads to New York. But these recoveries were made by hunting, and many of the birds may have moved after the breeding season before being subject to gunning.

More direct evidence came from birds banded on their breeding grounds and recovered in New York. The few records of this sort are shown in Table 3. These data suggest that Manitoba, Minnesota and North Dakota were important contributors of redheads taken in New York. Saskatchewan and Alberta also contributed. In the absence of records of the number banded, their relative importance cannot be appraised. Records presented by Lensink (1964) suggest a similar pattern of origin.

Weller (1964), using the records available to him, concluded that redheads reared in the eastern and northern portions of their range tended to migrate to the eastern wintering range. Those reared farther west in the prairie region tended to winter in Texas and Louisiana. No sharp dividing line separates these breeding populations.

Table 3. Redheads Banded within Limits of Breeding Range and Recovered in New York

Banding location	Age when banded				Total
	Duckling	Juvenile	Adult	Unknown	
Alberta	1	..	..	..	1
Saskatchewan	1	..	2	..	3
Manitoba	..	25	12	1	38
North Dakota	3	1	3	..	7
Minnesota	8	6	1	..	15
Total	13	32	18	1	64

Birds trapped during the winter on a wintering area might be assumed to be winter residents. For redheads banded in New York, this was true only if the wintering area was considered to encompass Chesapeake Bay and Pamlico Sound. About 47 per cent of the first-year recoveries occurred in migration north and west of the State (Table 2). About 2 per cent were taken in areas off the beaten track for redheads coming into the Atlantic Flyway. Of the remainder, almost equal proportions were taken in New York and wintering areas to the south. These proportions varied from year to year. That for New York in the years from 1955-56 through 1958-59 was 68, 33, 47 and 67 per cent, respectively.

On Canandaigua Lake in 1956, records were kept showing the dates on which birds banded there were recaptured during the same year. Table 4 summarizes these records. Approximately half the birds trapped

Table 4. Redheads Banded on Canandaigua Lake in 1956 and Retrapped There during the Same Year

Banded			Retrapped (per cent)							
Month	Number	Sex	January only	February only	March only	January and February	January February March	January and March	February and March	Total
January	183	Male	16.9	9.8	5.5	9.8	3.3	3.8	4.9	54.0
	60	Female	21.6	11.6	1.7	8.3	3.3	..	..	46.5
	748	Male	..	13.2	11.8	..	..	..	4.9	29.9
	158	Female	..	18.4	10.7	..	..	..	..	29.1
March	352	Male	..	..	50.0	..	..	..	..	50.0
	107	Female	..	..	36.4	..	..	..	..	36.4

in January were trapped again before the end of March. Over one-third were retaken in January, a quarter in February, and nearly 15 per cent in March. Only 3 per cent became regular visitors to the traps.

The interchange between banding stations is shown in Table 5. Only 209 birds, or 2 per cent, were retrapped the same year at other stations in New York than that where they were banded. This does not suggest much population interchange between lakes. Movement of redheads back and forth between Canandaigua Lake and Seneca Lake, which are less than 20 miles apart, was observed visually. The proportion of the birds that were banded on Seneca Lake and retrapped on Canandaigua Lake was greater than that of birds banded on Canandaigua Lake and retrapped on Seneca Lake. The birds recaptured at Dunkirk Harbor were taken in March after signs of the spring migration had been observed and westward movement had begun.

TABLE 5. REDHEADS BANDED AT ONE STATION AND RETRAPPED DURING THE SAME SEASON AT ANOTHER STATION IN NEW YORK FROM 1955 TO 1960

Station where banded	Number banded	Retrapped				
		Cayuga Lake	Seneca Lake	Canandaigua Lake	Dunkirk Harbor	Total
Cayuga Lake	90	xx	0	0	0	0
Seneca Lake	3,629	1	xx	163	5	169
Canandaigua Lake	5,759	1	28	xx	1	30
Dunkirk Harbor	910	0	1	9	xx	10

TABLE 6. REDHEADS BANDED AT CANANDAIGUA LAKE AND SENECA LAKE FROM 1955 TO 1959 AND RETRAPPED AT ONE OR THE OTHER OF THESE LAKES IN 1960*

Item	Year				
	1955	1956	1957	1958	1959
Banded at Seneca Lake					
Number banded	333	1,313	463	271	655
Number retrapped in 1960					
Seneca Lake	8	56	23	25	48
Canandaigua Lake	10	56	25	42	76
Banded at Canandaigua Lake					
Number banded	449	1,608	499	747	1,100
Number retrapped in 1960					
Canandaigua Lake	16	111	22	45	156
Seneca Lake	5	30	12	25	36

* In 1960 there were 594 new redheads banded at Seneca Lake, and 1,356 at Canandaigua Lake.

The recurrence at Canandaigua and Seneca Lakes in 1960 of redheads that were banded at these lakes from 1955 to 1959 is compared in Table 6. Of those banded at Seneca Lake, more were retrapped at Canandaigua Lake (6.9 per cent) than at Seneca Lake (5.3 per cent). Meanwhile 7.9 per cent of those banded at Canandaigua Lake were retrapped there and 2.4 per cent were retrapped on Seneca Lake. These birds seemed to be returning to a general area rather than a specific water unit. That greater numbers were retaken at Canandaigua Lake

probably was the result of the more intensive trapping done there—more traps, more trap sites and heavier baiting. Only 594 new birds were banded at Seneca Lake in 1960, while 1,356 were taken at Canandaigua Lake. The respective 5-year averages for the two lakes were 607 and 880.

MIGRATION ROUTE AND DISTRIBUTION OF RECOVERIES

The migration route of redheads into the Atlantic Flyway was illustrated by Weller (1964) and compared with that of the canvasback in a map modeled after one given by Stewart *et al.* (1958). The map illustrates that this portion of the redhead population, not unlike the canvasback, moves from Manitoba, North Dakota and Minnesota almost due east through Wisconsin and Michigan and along both shores of Lake Erie to funnel south and east from northwestern Pennsylvania and the Chautauqua Lake region of New York to Chesapeake Bay. A small segment reaches the eastern end of Lake Ontario (Canadian side) and the Finger Lakes of New York. Band returns for birds marked on their breeding range suggest that less than 25 per cent of the redheads that reach the Atlantic Flyway are subject to gunning in eastern Ontario and New York.

The distribution of first-year recoveries for redheads that were banded during the winter in New York (Table 2) shows essentially the same pattern of movement as that described by Weller (1964). About 19 per cent of these birds were subject to hunting within their breeding range. Another 20 per cent were taken in the areas touching the Great Lakes (exclusive of New York and that part of Ontario bordering on Lake Ontario). Less than 5 per cent were taken along the Canadian shore of Lake Ontario. About 2 per cent of the recovery records came from points scattered across the western flyways. The remainder were distributed nearly equally between New York and the other states of the Atlantic Flyway. Of the birds recovered south of New York the great majority were taken in Maryland, and in 1956-57 the number taken there exceeded that taken in New York.

Dates of recovery suggest that redheads banded during the winter in New York became available to gunning in Maryland about as soon as in New York. Aerial surveys showed migration patterns that closely followed that of recoveries. According to Stewart (1962) redheads first arrive in the Chesapeake Bay area in early October but become abundant between November 10 and December 10. Table 7 illustrates the progressive movement south and east as the fall advances, based on recovery records for birds banded in New York.

The relative numbers taken by hunting in New York and Maryland, according to one-third-month periods during the open season, are compared in Table 8. During October few redheads were taken in New

TABLE 7. DISTRIBUTION OF RECOVERIES BY HUNTING DURING THE 1955–56 TO 1960-61 SEASONS FOR REDHEADS BANDED DURING THE WINTER IN NEW YORK*

Recovery location	Time of recovery by one-third-month periods													Total
	September		October			November			December			January		
	2	3	1	2	3	1	2	3	1	2	3	1	2	
North and west of New York														
Alberta	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Saskatchewan	1	..	1	1	2	..	..	..	..	..	..	..	..	5
Manitoba	13	23	12	9	3	2	..	..	..	..	..	..	..	62
North Dakota	..	..	16	3	3	..	..	..	..	..	..	..	..	22
South Dakota	..	..	8	4	2	2	..	..	..	..	..	..	..	16
Minnesota	..	..	35	40	22	12	3	..	..	..	..	..	..	112
Wisconsin	..	..	4	9	11	10	6	..	..	..	..	..	..	40
Michigan	..	..	18	17	26	28	19	16	4	..	..	..	..	128
Ontario	..	6	6	8	12	13	15	24	12	12	..	..	..	108
Ohio	..	..	..	1	1	..	2	3	..	1	..	..	..	8
Sub-total	15	29	100	92	82	67	45	43	16	13	..	..	..	502
Per cent	3.0	5.8	19.9	18.3	16.3	13.3	9.0	8.6	3.2	2.6	..	..	..	100.0
New York														
New York	..	..	..	3	3	6	12	11	24	31	46	25	..	161
Per cent	..	..	..	1.9	1.9	3.7	7.4	6.8	14.9	19.1	28.5	15.5	..	100.0
South and east of New York														
Pennsylvania	..	..	..	..	3	..	1	1	2	1	..	..	..	8
New Jersey	..	..	..	..	..	..	..	1	1	..	5	1	..	8
Delaware	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Maryland	..	..	..	..	..	2	3	9	20	29	29	33	29	154
Virginia	..	..	..	..	..	..	2	1	2	3	..	3	6	17
North Carolina	..	..	..	..	..	..	2	1	4	3	..	2	..	12
Florida	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Quebec	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Massachusetts	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Rhode Island	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Connecticut	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Sub-total	..	..	..	..	3	2	9	14	29	37	36	39	36	205
Per cent	..	..	..	..	1.5	1.0	4.4	6.8	14.1	18.0	17.6	19.0	17.6	100.0
Other														
Wyoming	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Nebraska	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Kansas	..	..	..	1	2	..	..	..	..	..	..	..	..	3
Iowa	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Illinois	..	..	..	..	4	2	..	1	..	..	..	..	..	7

Table 7. *(continued)*

Recovery location	Time of recovery by one-third-month periods													Total
	September		October			November			December			January		
	2	3	1	2	3	1	2	3	1	2	3	1	2	
Missouri	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Kentucky	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Alabama	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Louisiana	..	..	..	..	..	1	1	1	..	..	..	..	..	3
Texas	..	..	..	..	..	..	1	..	..	1	..	..	..	2
Sub-total	..	..	..	4	7	4	2	2	..	1	1	..	..	21
Per cent	..	..	..	19.0	33.4	19.0	9.5	9.5	..	4.8	4.8	..	..	100.0
Total	15	29	100	99	95	79	68	70	69	82	83	64	36	889
Per cent	1.7	3.3	11.2	11.1	10.7	8.9	7.7	7.9	7.8	9.2	9.3	7.2	4.0	100.0

* Does not include some records in Table 2 for which actual date of recovery was not known.

York, and there was no open season in Maryland during this month in any of the years studied. During November the take in both states was proportional to the days of hunting opportunity. Through December and early January, recoveries increased in relation to the days of opportunity, but the increase was greater in New York. The high rate of harvest in relation to opportunity in New York for the last third of December and the first third of January is misleading. Many of these birds were taken in 1958-59 when the second part of a split season was accompanied by almost ideal weather for hunting diving ducks, i.e., extreme cold, winds and storms. The total recovery per hunting day for the entire period was almost identical——0.44 in New York and 0.42 in Maryland.

A clue to migration routes and possible reasons why this redhead population became available to hunting in Maryland as soon as in New York is the date of banding in relation to the place of recovery. If some of these birds flew south directly to Chesapeake Bay, but worked northward through the Finger Lakes in late winter, it is possible that the banding done in New York was really sampling two populations. This hypothesis may be examined by comparing the recoveries for New York and Maryland alone (Table 9). These records show that 58 per cent of the recoveries for birds banded from January through March 10 came from New York, while nearly 75 per cent of those for birds banded after March 10 came from Maryland. It appears then that redheads present in New York in January and February were in part a

TABLE 8. COMPARATIVE RECOVERIES IN NEW YORK AND MARYLAND, ACCORDING TO ONE-THIRD-MONTH PERIODS AND NUMBER OF HUNTING DAYS, FOR REDHEADS BANDED DURING THE WINTER IN NEW YORK FROM 1955 TO 1960 AND SUBSEQUENTLY SHOT DURING THE SEASONS OF 1955–56 TO 1959–61

Item	Month and period										Total
	October		November			December			January		
	1	2	1	2	3	1	2	3	1	2	
New York											
Recoveries											
Number	3	3	6	12	11	24	31	46	25	..	161
Per cent	1.9	1.9	3.7	7.5	6.8	14.9	19.3	28.5	15.5	..	100.0
Hunting days*	31	66	60	60	55	36	30	18	8	0	364
Recoveries per day	0.10	0.05	0.10	0.20	0.20	0.66	1.03	2.56	3.12	..	0.44
Maryland											
Recoveries											
Number	..	..	2	3	9	20	29	29	33	29	154
Per cent	..	..	1.3	1.9	5.9	13.0	18.8	18.8	21.5	18.8	100.0
Hunting days*	0	0	12	37	60	60	60	66	55	20	370
Recoveries per day	..	..	0.17	0.08	0.15	0.33	0.48	0.44	0.60	1.45	0.42

* Total number for all seasons combined; selection of split season in New York in 1958–59 reduced hunting there by 6 days.

TABLE 9. COMPARATIVE HARVEST IN NEW YORK AND MARYLAND DURING SEASONS FROM 1955–56 TO 1960–61 FOR REDHEADS BANDED DURING THE WINTER IN NEW YORK FROM 1955 TO 1960 ACCORDING TO PERIOD OF BANDING

Item	Time of banding by one-third-month period									Total
	January			February			March			
	1	2	3	1	2	3	1	2	3	
Recoveries										
New York	5	25	28	22	20	22	22	9	8	161
Maryland	3	20	18	13	19	9	22	24	26	154
Percentage in New York	62.5	55.5	60.9	62.9	51.3	71.0	50.5	27.3	23.5	51.1

terminal wintering population and in part birds that tended to winter south of New York. Perhaps up to a quarter of the birds wintered either place depending on weather or flock leadership. Recovery rates in the two states for birds trapped each month were nearly equal.

SEX RATIOS AMONG THE BIRDS BANDED

The proportion of females among the redheads banded ranged from about 16 to 29 per cent (Table 10). From 1955 through 1957 it increased, and from 1958 through 1960 it declined. The average for the six years was 21.5 per cent. This indicated that production during the bumper years on the prairie potholes was good and that the addition of young was bringing the sex ratio into better balance. Supplemental data included in Table 10 give the sex ratios of redheads banded from 1961 to 1964, a period when no hunting was allowed on this species in the United States. The numbers trapped in 1961 and 1962 were too few to constitute good samples, but the samples for 1963 and 1964 were large and comparable to those for 1955 to 1960. They indicate no change in the sex ratio. Similar sex ratios were observed when flocks were studied with field glasses and telescopes. Therefore it is assumed that

Table 10. Comparative Proportions of Females among Redheads Banded in New York from 1955 to 1960 and from 1961 to 1964

Year	Number banded			Proportion of females (per cent)			
	Male	Female	Total	January	February	March	Total
1955–1960							
1955	705	201	906	18.9	18.2	27.2	22.2
1956	2,549	827	3,376	26.7	19.1	30.0	24.5
1957	858	343	1,201	28.9	24.9	30.5	28.6
1958	887	246	1,133	28.1	19.9	18.6	21.7
1959	1,520	303	1,823	17.0	15.6	17.2	16.6
1960	1,640	309	1,949	17.7	12.6	16.4	15.8
Average	xxx	xxx	xxx	23.7	17.8	23.0	21.5
Total banded	8,159	2,229	10,388	3,122	3,490	3,776	10,388
1961–1964							
1961	177	73	250	29.1	23.4	42.9	29.2
1962	355	87	442	19.8	25.4	12.7	19.7
1963	1,855	405	2,260	20.0	16.2	11.4	17.9
1964	1,978	740	2,718	27.3	23.8	30.6	27.2
Average	xxx	xxx	xxx	24.1	21.3	19.5	23.0
Total banded	4,365	1,305	5,670	4,009	783	878	5,670

males and females were being taken in the traps in proportion to their occurrence.

Recovery locations indicated that redheads banded during the last two-thirds of March were four times as likely to be taken south of New York as in New York. Birds banded during January and February were 1.7 times as likely to be taken in New York. Sex ratios for those trapped in March showed no difference either by one-third-month periods or in comparison with the annual totals. This suggests that there was no difference between the proportion of females in the population wintering in New York and that in populations wintering farther south.

MORTALITY AND SEX DIFFERENTIALS

First-year recovery rates for redheads banded from 1955 through 1958 were relatively constant (Table 11), but in 1959 the rate dropped to 2.8 per cent. In both the 1958-59 and 1959-60 seasons only one redhead or canvasback was allowed in the bag. The selection of a late split season in New York in 1958-59 and excellent weather for hunting diving ducks countered the effect of the reduced bag in that year. These rates were higher than those for canvasbacks on the same areas from 1955-56 to 1957-58 (7.4, 6.6 and 6.1 per cent, respectively) as reported by DeGraff *et al.* (1961). In 1958-59 the rate for canvasbacks jumped to 12.0 per cent under the late split season. Mortality rates based on three hunting seasons do not give a full picture since the redhead may live to three times that age. Rates calculated from Table 11 only suggest that the females had a higher rate than the males. The canvasback records, however, showed a definitely higher mortality rate for females than males.

The open seasons and bag limits in effect during these years are summarized in Table 12. Since redheads usually arrive in New York earlier in the fall than canvasbacks, seasons that extend only into mid-December would tend to provide a higher rate of harvest by hunting for redheads than canvasbacks. The proportion of the canvasback harvest that occurs in New York is usually about 29 per cent, but in 1958-59 it was 72 per cent. For redheads, the corresponding figures were 21 per cent and 42 per cent.

Records for retrapped birds also indicate mortality rates. Such records from 1956 through 1964 for birds banded from 1955 to 1960 are given in Table 13. Only records from Canandaigua Lake and Seneca Lake are used because personnel and effort remained more constant at these two stations from 1955 through 1964 than at the other stations shown in Table 1. These data show a more rapid loss of females than males. The first year after banding, only two-thirds as many females as males were retrapped, and over all nine years only half as many were retrapped.

Table 11. Recoveries by Hunting, According to Year of Banding and Year of Recovery, for Redheads Banded in New York

Banded			Recovered													
			1955–56		1956–57		1957–58		1958–59		1959–60		1960–61		Total	
Year	Number	Sex	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1955	704	Male	60	8.5	27	3.8	10	1.4	25	3.6	6	0.9	2	0.3	130	18.5
	201	Female	19	9.5	9	4.5	6	3.0	2	1.0	1	0.5	..	..	37	18.4
	905	Total	79	8.7	36	4.0	16	1.8	27	3.0	7	0.8	2	0.2	167	18.5
1956	2,549	Male	..	..	169	6.6	116	4.6	71	2.7	46	1.8	6	0.2	408	16.0
	827	Female	..	..	69	8.3	32	3.9	18	2.2	8	1.0	..	..	127	15.4
	3,376	Total	..	..	238	7.0	148	4.4	89	2.6	54	1.6	6	0.2	535	15.8
1957	858	Male	..	..	..	..	72	8.4	31	3.6	19	2.2	2	0.2	124	14.5
	343	Female	..	..	..	..	29	8.5	6	1.7	4	1.2	1	0.3	40	11.7
	1,201	Total	..	..	..	..	101	8.4	37	3.1	23	1.9	3	0.2	164	13.7
1958	887	Male	..	..	..	..	..	..	68	7.7	23	2.6	4	0.5	95	10.7
	246	Female	..	..	..	..	..	..	26	10.6	9	3.7	..	..	35	14.2
	1,133	Total	..	..	..	..	..	..	94	8.3	32	2.8	4	0.4	130	11.5
1959	1,520	Male	..	..	..	..	..	..	..	..	41	2.7	3	0.2	44	2.9
	303	Female	..	..	..	..	..	..	..	..	10	3.3	..	..	10	3.3
	1,823	Total	..	..	..	..	..	..	..	..	51	2.8	3	0.2	54	3.0
1960	1,641	Male	..	..	..	..	..	..	..	..	..	..	2	0.1	2	0.1
	309	Female	..	..	..	..	..	..	..	..	..	..	2	0.6	2	0.6
	1,950	Total	..	..	..	..	..	..	..	..	..	..	4	0.2	4	0.2

Table 12. Open Seasons and Bag Limits for Redhead and Canvasback in Effect in New York from 1955–56 to 1960–61

Year	Open season		Bag limit	
	Dates	Total days	Total ducks	Redhead and canvasback
1955–56	October 15–December 23	70	4	4 in aggregate
1956–57	October 15–December 23	70	4	4 in aggregate
1957–58	October 19–December 27	70	4	4 in aggregate
1958–59	October 16–November 25 and December 27–January 8	54	4	2 in aggregate
1959–60	October 16–December 4	50	3	1 in aggregate
1960–61	October 14–December 2	50	3	None

The recovery data in Table 11 show that female redheads were more vulnerable than males to hunting during the first fall following banding. The dates of recovery also indicate that females were somewhat more likely to be shot early in the season than males. Among the birds banded in 1955 recovery rates were also higher for females during the second and third seasons, but they were higher for males after that. At the end of six shooting seasons the total recovery rates for males and females were nearly equal, i.e., 18.5 and 18.4 per cent, respectively. For the birds banded in 1956, recovery rates were higher for males than females during all seasons except the first, but again the total recovery rates were similar, i.e., 16.0 per cent for males and 15.4 per cent for females. Total recovery rates for later years are less meaningful because of fewer years' records and reduced bag limits. First-year recoveries for the six years averaged 5.05 per cent for males and 6.95 per cent for females indicating that the females were 1.38 times as vulnerable to hunting as the males. That males and females provided nearly equal returns after 6 years indicated that the observed differential in sex ratio was partly due to gunning, most females being removed from the population in about 3 years while many males lived much longer.

Bellrose *et al.* (1961) in their very thorough review of sex and age ratios in North American ducks brought together a wealth of sex ratio data, some of which pertains to redheads. They cited Sowls (1955) as showing that 53.8 per cent of 636 redhead ducklings at hatching were males. Hunter bag checks in Manitoba and the Mississippi Flyway states were reported to include 46.6 to 52.8 per cent males in the immature redheads taken during the years 1946 to 1949 in samples totalling 2,992 birds. The average of 50.7 per cent males in the bag suggests a differential harvest of females over males when compared with the sex ratio at hatching. With juveniles making up 85.3 per cent of the

Table 13. Survival of Redheads in Terms of Proportions of Birds Banded at Canandaigua and Seneca Lakes from 1955 to 1960 That Were Retrapped, According to Number of Years after Banding, until 1964

Birds banded		Number of years after banding								
Year	Number	1	2	3	4	5	6	7	8	9
					Males retrapped					
1955	602	72	13	15	39	39	6	3	8	0
1956	2,255	92	65	230	231	33	20	48	13	..
1957	671	28	68	69	21	8	32	9	..	..
1958	804	164	116	25	18	69	27	..	..	..
1959	1,473	284	58	41	161	80	..	..	..	..
1960	1,641	62	49	221	85	..	..	..	..	..
Total		702	369	601	555	229	85	60	21	0
Per cent*		9.4	5.0	8.1	7.5	3.9	2.0	1.7	0.7	0.0
					Females retrapped					
1955	180	15	3	0	2	1	0	0	0	0
1956	666	24	9	23	20	5	2	1	1	..
1957	291	4	18	18	5	1	8	6	..	..
1958	214	32	21	7	3	7	0	..	..	..
1959	282	32	11	5	14	5	..	..	..	..
1960	309	18	10	17	5	..	..	..	..	..
Total		125	72	70	49	19	10	7	1	0
Per cent*		6.4	3.7	3.6	2.5	1.2	0.7	0.6	0.1	0.0
					Cumulative number banded					
Male	7,446	7,446	7,446	7,446	7,446	5,805	4,332	3,528	2,857	602
Female	1,942	1,942	1,942	1,942	1,942	1,633	1,351	1,137	847	180

* Proportion of cumulative number banded for each period.

§ Figures represent number of birds potentially available for retrapping in each case with no allowance for mortality. For the 1- to 4-year periods, the figures are the same because records for birds banded after 1960 were not used.

harvest, marked differentials in sex ratio would be expected in the population reaching New York.

The records of a banding station on Seneca Lake where all redheads were examined cloacally are summarized in Table 14. The proportions of females were similar for the adults and juveniles banded, averaging 22.6 and 24.2 per cent, respectively, for the 5 years from 1955 to 1959. Apparently the immature females had been subject to heavy mortality before reaching New York. Based on the same records, the proportions of juveniles for the two sexes are summarized in Table 15. Among the males the average declined from January to March.

Table 14. Proportion of Females, Based on Cloacal Examination, among Redheads Banded at Seneca Lake from 1955 to 1959*

Year	January				February				March				Total			
	Adult		Juvenile		Adult		Juvenile		Adult		Juvenile		Adult		Juvenile	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	Number banded															
1955	126	26	6	3	38	11	13	3	61	23	11	12	225	60	30	18
1956	363	165	183	52	258	71	79	17	73	27	16	9	694	263	278	78
1957	121	48	96	45	54	18	29	13	31	5	2	1	206	71	127	59
1958	..	..	..	..	100	14	32	5	93	14	8	5	193	28	40	10
1959	31	7	5	0	373	78	42	4	88	21	6	0	492	106	53	4
Total	641	246	290	100	823	192	195	42	346	90	43	27	1,810	528	528	169
	Proportion of females (per cent)															
1955	17.1		33.3		22.9		18.8		27.4		52.2		21.1		37.5	
1956	31.3		21.3		21.6		17.7		27.0		36.0		27.5		21.9	
1957	28.4		31.9		25.0		30.9		13.9		33.3		25.6		31.7	
1958	..		..		12.3		13.5		13.1		38.5		12.7		20.0	
1959	18.4		0.0		17.3		8.7		19.3		0.0		17.7		7.0	
Total	27.7		25.6		18.9		17.7		20.6		38.5		22.6		24.2	

* Station operated by Dr. Richard A. Ryan of Hobart College.

Table 15. Proportion of Juveniles, Based on Cloacal Examination, among Male and Female Redheads Banded at Seneca Lake from 1955 to 1959*

Year	January		February		March		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
1955	4.5	10.3	25.5	21.4	15.3	34.2	11.8	23.1
1956	33.5	24.0	23.4	19.3	18.0	25.0	28.6	22.9
1957	44.2	48.4	34.9	41.9	6.1	16.7	38.1	45.4
1958	..	..	24.2	26.3	7.9	26.3	17.2	26.3
1959	13.8	0.0	10.1	4.9	6.4	0.0	9.7	3.6
Total	31.1	28.9	19.2	17.9	11.1	23.1	22.6	24.2

* Derived from figures for numbers banded given in Table 14.

Among the females there was a less pronounced decline, but the sample was small. During January no birds were handled that could not be definitely classified as adult or juvenile. In February some juveniles, and in March more, were taking on adult characters. Where doubt existed as to age, the birds were classed as adult. Changing characters on males were observed more easily and perhaps sooner than on the females.

DISCUSSION

Because they are both diving ducks that frequent the larger water areas of upstate New York that stay open through the winter, there is a tendency to consider redheads and canvasbacks as a common group. This is only partially justified. The data presented here show how the redhead differs, with respect to migration and the effects of hunting as reflected in the records for birds banded in New York during the winter, from the canvasback as discussed by DeGraff *et al.* (1961). They also indicate some of the problems in managing this species that crosses country and flyway boundaries.

Redheads reared in the eastern and northern portions of their breeding range, primarily Manitoba, Minnesota and eastern North Dakota, tend to winter in the Atlantic Flyway including New York. Canvasbacks that reach New York follow the same pattern, but a larger proportion of this species than of the redhead probably comes from Saskatchewan. In fall migration the two species follow similar routes through the Great Lakes region. Based on band recoveries the peaks of movement of the two species roughly coincide. Redheads perhaps move earlier and more gradually. Both may be taken in New York in October in small numbers. The redhead harvest increases in early November and then may jump sharply with the arrival of mid-November flights. The canvasback harvest does not become significant until late November.

Both species become progressively more vulnerable to gunning in December if the weather becomes severe. Harvest rates, especially for the canvasback, are controlled more by weather than by the relative numbers of birds in the area. More canvasbacks than redheads are normally observed during aerial surveys in November in New York, yet redheads are more likely to be shot. Conversely, late December and early January shooting results in more canvasbacks than redheads being taken.

For birds banded during the winter in New York, about 56 per cent of the recoveries for redheads came from north and west of this State, while the corresponding figure for canvasbacks was 24 per cent. Recoveries in New York amounted to 18 per cent and 51 per cent, respectively. These represented total recoveries and included those during the split season in 1958-59 when canvasbacks were very vulnerable to gunning in this State. If the data for 1958-59 are omitted, the proportions would become 43 per cent for the area to the north and west and 29 per cent for New York. But such an adjustment would have no significant effect on the recovery values for the redhead. For both species, only 20 to 30 per cent of the recoveries came from south and east of New York.

The lateness of the second half of the split season in 1958-59 (December 27-January 8) resulted in the recovery of banded canvasbacks rising to 12 per cent, almost double the average for the three preceding seasons. That for redheads, however, remained essentially unchanged. Since the bag limits for both species were lowered in that year, the lack of reduction in recovery rate for the redhead represented some compensating increase in the harvest which applied to redheads to a much greater degree than to canvasbacks. The data suggest that the dates of the open season in New York could be adjusted with respect to the number of shooting days allowed in late December and January so as to reduce the harvest of redheads only slightly while reducing that of canvasbacks substantially.

These data for the redhead and those reported by DeGraff *et al.* (1961) for the canvasback both suggest that gunning results in a relatively higher loss of juvenile females than of juvenile males. This loss occurs primarily in the prairie states and provinces, and by the time birds of the year reach New York males predominate. Similarly, for winter-banded birds of both species, recoveries by hunting during the first fall after banding is higher for females than for males. As Bellrose *et al.* (1961) have pointed out, the high mortality rates among immature redheads result in a relatively large proportion of old birds among the adults and a preponderance of males. Hickey (1952) concluded that hunting losses amount to about 50 per cent for juveniles but only about 20 to 30 per cent for adults, while annual mortality rates are about 70 per cent for juveniles and 55 per cent for adults. In the present study

adult females were found to be 1.38 times as vulnerable to gunning as adult males.

There is need for hunting regulations that would reduce the high loss of female redheads that occurs early in the season and that is most pronounced during the first year or two of life. In any case, hunters could help by passing up females in favor of males. In New York, this would be especially applicable in the Finger Lakes region.

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HISTORY AND EPIDEMIOLOGY OF RABIES IN WILDLIFE IN NEW YORK[1]

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ABSTRACT

Rabies was present in New York State in the early 1900's, chiefly in the lower Hudson Valley and near other population centers such as Rochester and Buffalo. Over the next 40 years it spread to much of the remainder of the State. Dogs were the principal source of infection, but by 1948 immunization and stray dog control had virtually eliminated it in this species.

However, several wildlife species have replaced the dog as the major vectors of the disease in recent years. Although the first laboratory-confirmed case among wildlife was in a skunk in 1929, this species has only recently become an important vector in this State. The fox has been the primary vector. Outbreaks have mainly involved domestic livestock. The number of cases in humans has been minor.

The first significant epizootic occurred during the summer of 1945 among foxes in central Broome County, and since then there have been outbreaks in other parts of the State. The incidence has shown periodic fluctuations with peaks every four to five years that generally coincide with highs in fox populations. The disease occurs throughout the year, but is most prevalent in April, August and October.

"Canine madness continues to prevail at different points from the eastern to the western limits of the State when well directed measures, such as those in force in England would have speedily banished it." This quotation from the Annual Report of the New York State Veterinary College for 1905 indicates that rabies was well established within the State at the turn of the century. Now, 62 years later, rabies has expanded its range and is reported in nearly all areas of the State. Along with this a change has also occurred in the species involved in transmitting and maintaining the disease. This change has been from a domestic vector, the dog, to a number of wildlife vectors such as the fox, skunk, raccoon and bat.

In this paper the general history of rabies in New York State (exclusive of New York City) is reviewed, and its current status is summarized. Special emphasis is placed on the changing role of wildlife in the epidemiology of the disease.

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HISTORY

Rabies is one of the earliest diseases known to mankind. References to it can be found in the writings of such early scholars as Aristotle, Pliny and Celus. Records of its occurrence in New York State date back to colonial days (Korns and Zeissig, 1948). Diagnosed cases of human deaths from this malady in upstate New York can be found in 19th century medical records (Medical Society of the County of Albany, 1851-1870). For purposes of discussion four time periods are considered: 1899 to 1925, 1926 to 1940, 1941 to 1960, and 1961 to the present.

Period from 1899 to 1925

Prior to 1925 no central laboratory or office was responsible for diagnosing or tabulating and reporting rabies incidence. As a result, records are incomplete and do not give a true picture of rabies incidence for much of the period. The control of rabies was a function of the Department of Agriculture and Markets, and diagnostic laboratory work was carried out at the New York State Veterinary College at Ithaca.

Table 1. Incidence of Rabies in New York State from 1898–99 to 1925–26*

Year§	Number examined	Number positive	Number negative	Number undetermined	Percentage positive
1898–99	1	0	1	0	0.0
1899–00	1	0	1	0	0.0
1900–01	11	8	0	3	72.7
1901–02	8	1	6	1	12.5
1902–03	3	2	0	1	66.7
1903–04	36	25	5	7	69.4
1904–05	26	16	4	6	61.5
1905–06	32	16	6	10	50.0
1906–07	63	36	18	9	57.1
1907–08	315	188	94	33	59.7
1908–09	588	295	256	37	50.2
1909–10	329	143	156	30	43.5
1910–11	182	86	81	15	47.3
1911–12	180	85	85	10	47.2
1912–13	285	159	109	17	55.8
1913–14	490	251	204	35	51.2
1914–15	325	157	145	23	48.3
1915–16	108	48	56	4	44.4
1916–17	190	86	92	12	45.3
1917–18	210	91	100	19	43.3
1918–19	285	143	105	37	50.2
1919–20	122	48	66	8	39.3
1920–21	56	7	41	8	12.5
1921–22	39	6	28	5	15.4
1922–23	57	14	39	4	24.6
1923–24	72	5	67	0	6.9
1924–25	60	8	52	0	13.3
1925–26	81	26	49	6	32.1

* From annual reports of New York State Veterinary College at Ithaca.
§ For years beginning October 1 and ending September 30.

The first laboratory-diagnosed cases of rabies in the State were reported in the year 1900-01 when eight of 11 specimens submitted to the diagnostic laboratory of the Veterinary College were found to be positive (Table 1). Increased awareness of and interest in the disease contributed to a three-fold increase in both specimens submitted and positive cases diagnosed during 1903-04. This trend continued, and 588 specimens were submitted in 1908-09, of which 295 were diagnosed as positive for rabies.

Initially, rabies was concentrated in the lower Hudson Valley and near other population centers such as Rochester and Buffalo. The disease was primarily one of dogs with secondary involvement of livestock, cats and man. Cattle losses during any given year were low despite the relatively high incidence among dogs in some areas. Reported losses among cattle seldom exceeded two dozen and usually were less than one dozen head per year. Lesser numbers of other domestic animals were infected.

Period from 1926 to 1940

During 1926 the responsibility for controlling rabies was delegated by law to the State Department of Health. This, coupled with a previous amendment to the State Sanitary Code in 1921 which made it the duty of every physician or other person to report anyone bitten by a rabid animal to the local health officer, laid the groundwork for the surveillance and reporting of rabies occurrence throughout the State.

With this improved system and an increased interest in the disease, reports of rabies infection became more commonplace. One of the first outbreaks to be reported was among dogs in the city of Binghamton in Broome County in 1927. This was associated with a high incidence of rabies in the bordering counties of Pennsylvania. By 1928, a localized occurrence of rabies in the lower Hudson Valley was reported to have spread up both sides of the Hudson River from New York City. It also was reported that an additional focus had been discovered in Franklin County during the previous year and was the result of a spreading infection from Vermont (N.Y.S. Dept. of Health, 1929).

A decrease in the number of reported cases occurred in 1928, and this trend continued for the next five years after which a gradual increase again took place (Table 2). Although total incidence declined, the number of counties reporting rabies was increasing. In 1931 rabies was present in 15 counties, but the majority of cases still occurred in the Hudson Valley.

As in previous years, the dog was the primary species involved. During the 1925-1940 period, 1774 of 1813 reported cases were among dogs. Reported incidence among other animals was negligible. However, it was during this period that the disease was first reported from a wildlife species (Table 2).

Table 2. Reported Incidence of Rabies by Species from 1925 to 1940 in New York State, Exclusive of New York City *

Year	Dog	Cattle	Cat	Fox	Skunk	Man	Total
1925	130	0	1	0	0	1	132
1926	195	0	1	0	0	0	196
1927	238	3	2	0	0	0	243
1928	218	2	1	0	0	4	225
1929	204	2	1	0	1	1	209
1930	142	1	3	0	0	2	148
1931	70	1	1	0	0	0	72
1932	48	0	1	0	0	0	49
1933	18	0	0	0	0	0	18
1934	21	0	0	0	1	0	22
1935	29	3	0	0	0	0	32
1936	69	1	1	0	0	0	71
1937	62	0	0	0	1	0	63
1938	75	0	0	0	0	0	75
1939	155	1	0	0	0	0	156
1940	100	2	0	0	0	0	102
Total	1,774	16	12	0	3	8	1,813

* From records of State Department of Health.

The first case in wildlife, a skunk from Rensselaer County, was diagnosed in 1929. Five years later a second case, and three years after that a third, were reported. Both involved skunks from Westchester County in the lower Hudson Valley. These records came to light after the work of Linhart (1960).

Other cases of rabies in wildlife undoubtedly occurred in the State during this and earlier periods, but they were not confirmed by laboratory diagnosis or reported upon. Several non-confirmed reports of an outbreak among foxes along the St. Lawrence River at the turn of the century have been brought to the author's attention.

Period from 1941 to 1960

This period was one of great change in the rabies situation in the State. It was during the early 1940's that rabies problems of the sort

Figure 1. Reported cases of rabies among wildlife in New York State (exclusive of New York City) prior to 1945.

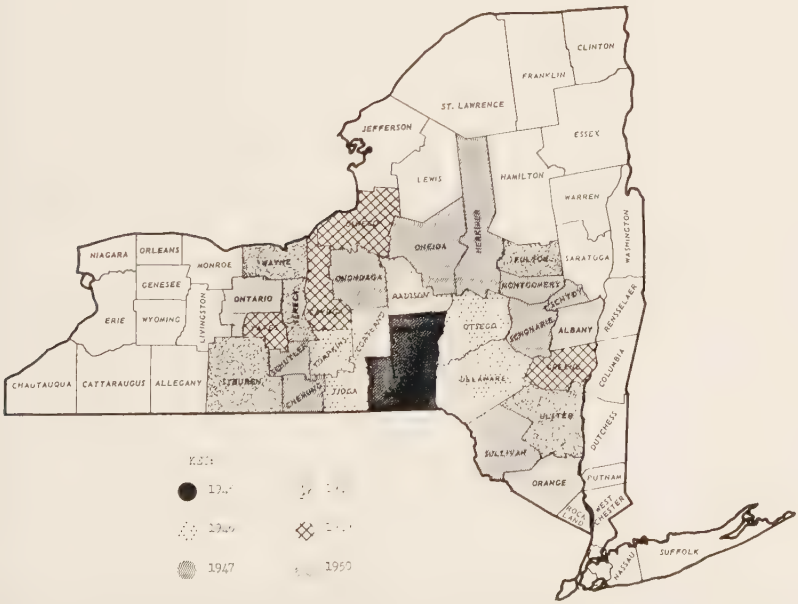

Figure 2. Spread of rabies among foxes in New York State from the epizootic of 1945 until 1950.

Table 3. Reported Incidence of Rabies by Species from 1941 to 1965 in New York State, Exclusive of New York City*

Species	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
Cattle	0	0	10	47	87	440	329	225	172	367	214	174	210
Horse	0	1	0	3	1	9	7	6	3	3	3	8	3
Swine	0	0	0	0	4	5	2	4	3	6	3	0	0
Sheep	0	0	0	0	1	2	6	7	3	15	13	0	0
Goat	0	0	0	2	0	3	0	0	0	0	0	0	0
Dog	107	62	176	233	503	377	52	23	16	37	48	16	44
Cat	1	0	1	12	15	19	18	24	20	62	51	26	42
Monkey	0	0	0	0	0	0	0	0	0	0	0	0	0
Fox	1	0	1	15	50	309	275	258	278	497	183	101	129
Raccoon	0	0	0	1	0	11	6	18	16	28	20	11	5
Skunk	0	1	0	0	0	0	0	2	1	6	3	0	1
Bat	0	0	0	0	0	0	0	0	0	0	0	0	0
Deer	0	0	0	0	0	0	0	1	2	1	0	1	1
Coydog	0	0	0	0	0	0	1	0	0	0	0	0	0
Rabbit	0	0	0	0	1	0	0	0	1	0	0	0	0
Woodchuck	0	0	0	0	0	0	0	0	0	0	0	0	1
Otter	0	0	0	0	0	0	0	0	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0
Squirrel	0	0	1	0	0	0	0	0	0	0	0	0	0
Fisher	0	0	0	0	0	0	0	0	0	0	0	0	0
Man	0	0	0	1	1	0	0	0	0	0	1	0	1
Total	109	64	189	314	663	1,175	696	568	515	1,022	539	337	437

Table 3. (*continued*)

Species	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	Total
Cattle	250	240	133	110	146	253	152	22	37	10	18	56	3,702
Horse	4	4	0	1	2	4	2	1	2	2	1	6	76
Swine	0	7	0	0	0	1	1	0	0	0	0	1	37
Sheep	2	3	4	0	5	3	12	3	0	0	2	1	82
Goat	2	0	0	0	0	0	1	0	0	1	0	0	9
Dog	26	42	37	13	21	22	23	4	7	7	5	7	1,908
Cat	23	37	22	26	21	47	48	9	4	6	2	6	542
Monkey	0	0	0	0	0	0	0	0	0	1	0	0	1
Fox	155	168	99	49	56	127	186	25	43	40	49	100	3,194
Raccoon	9	15	7	2	7	6	11	3	2	2	0	0	180
Skunk	1	2	3	1	0	6	17	11	3	12	33	66	169
Bat	0	0	1	0	2	1	2	14	8	8	11	14	61
Deer	0	0	0	0	0	2	0	0	0	0	0	0	8
Coydog	0	0	0	0	1	0	0	0	1	0	0	0	3
Rabbit	0	0	0	0	0	1	0	0	0	0	0	0	3
Woodchuck	0	0	0	0	0	0	0	0	0	0	0	1	2
Otter	0	1	0	0	0	0	0	0	0	0	0	0	1
Beaver	0	0	0	0	0	1	0	0	0	0	0	0	1
Squirrel	0	0	0	0	0	1	0	0	0	0	0	0	2
Fisher	0	0	0	0	0	0	0	0	0	0	0	1	1
Man	0	0	0	0	0	0	0	0	0	0	0	0	4
Total	472	519	306	202	261	475	455	92	107	89	121	259	9,986

* From records of State Department of Health.

existing today were first encountered. Wildlife involvement began slowly with a rabid fox being diagnosed in 1941, a skunk in 1942 and a second fox and a squirrel in 1943. These four cases occurred in widely separated counties (Figure 1). However, the first multiple incidence among wildlife species from a single county quickly followed in 1944 when rabies was diagnosed in 15 foxes, 1 raccoon, 8 cats, 41 cattle and 1 human in Chautauqua County.

This outbreak was followed by a major epizootic during the summer of 1945 among foxes in central Broome County in the southcentral part of the State. From this second focal point rabies rapidly spread eastward, westward and northward while the Chautauqua County infection apparently died out (Figure 2).

With a major epizootic in foxes underway, rabies incidence began to climb rapidly. The number of cases rose from 189 in 1943 to 314 in 1944, doubled in 1945 and nearly doubled again in 1946 when, 1,175 laboratory-diagnosed cases were reported (Table 3).

Widespread use of immunizing vaccine was undertaken in 1946 and 1947 to combat the disease in dogs, and by 1948 rabies in dogs was no longer considered a serious problem in New York State. Despite the spectacular success of this program, rabies incidence remained high apparently because of the fox. The fox had taken on new importance in the epidemiology of the disease, and 497 cases were reported among fox populations during 1950. Associated with this high incidence among foxes was a correspondingly high incidence among domestic livestock and increased involvement of other species (Table 3).

Generally, rabies persisted over much of the southcentral portion of the State during this entire period. Additional outbreaks in the three-county area of Wyoming, Cattaraugus and Allegany Counties further extended the spread westward in 1959, and by 1960 this had reached into the neighboring counties of Erie and Genesee.

During the late 1950's rabies incidence began to subside in the hard-hit Catskill region and other eastern counties where previous infection rates had been high. By 1960 the combined incidence in Delaware and Otsego Counties had dropped to a single case. In 1947, two years after the epizootic in Broome County, 175 cases had been reported from these same two counties.

Period from 1961 to Present[2]

The period from 1961 through 1964 was one of generally low rabies incidence following the two high years of 1959 (475 cases) and 1960 (455 cases). Reported incidence dropped to 92 cases during 1961 and reached a low of 89 in 1963 (Table 3).

[2] Represents mid-1966 when this paper was written.

But, while the reported incidence was dropping elsewhere, a new outbreak was developing along the St. Lawrence River in northern New York. Seventeen cases were diagnosed from St. Lawrence County during 1961, the first ever confirmed from that county. The following year there were 29 cases there, and cases also occurred in the neighboring counties of Franklin and Clinton. The outbreak continued during 1963 and in 1964 spread to adjoining Jefferson County. The total incidence for these four counties in 1964 was 92 cases. This nearly doubled during 1965 and all four counties reported cases in 1966. (Table 4).

TABLE 4. REPORTED INCIDENCE OF RABIES IN THE ST. LAWRENCE RIVER REGION FROM 1961 TO 1966

County	1961	1962	1963	1964	1965	1966*
St. Lawrence	17	29	15	19	106	40
Franklin	0	20	15	23	25	8
Clinton	0	13	11	36	31	8
Jefferson	0	0	0	14	19	56
Total	17	62	41	92	181	112

* Through June 30.

Rabies now appears to be on the increase again in New York. Associated with this increase is the predominence of infection in skunks in local areas, illustrating for the first time in this State the potential importance of this species as a vector of rabies. During 1964 the statewide incidence of rabies among skunks was 33 cases, nearly double the previous high of 17 in 1960. It increased to 66 in 1965, and 28 skunk cases were reported for the first half of 1966.

EPIDEMIOLOGY

Two facts are evident from the preceding review of the history of rabies in wildlife in New York. First, the reported incidence has varied widely since 1925 (18 cases during 1933 and 1,175 during 1945). Second, there have been major changes in the relative importance of potential vector species. This second observation, including the relationship of these vector species to the spread of rabies within the State, is discussed here.

In New York State, as in many other areas, rabies was first associated with dogs and areas of dense human population. This relationship has changed dramatically during the past 20 years, and now rabies is chiefly associated with the fox and skunk. Immunization, stray dog con-

Table 5. Comparative Incidence of Rabies in New York State, Exclusive of New York City, Before and After Wildlife Became Important as Vectors

Year	Counties reporting rabies	Number of cases	
		In wildlife	In species other than wildlife
Wildlife not important as vectors			
1936	5	0	71
1937	5	1	62
1938	5	0	75
1939	10	0	155
1940	8	0	102
1941	9	1	107
1942	9	1	113
1943	13	2	187
Average	8.0	0.6	109.0
Wildlife important as vectors			
1944	18	16	297
1945	19	51	612
1946	25	320	855
1947	23	282	414
1948	23	279	289
1949	26	298	217
1950	29	532	490
1951	23	206	332
1952	26	113	224
1953	28	137	299
1954	22	165	307
1955	22	186	333
1956	26	110	196
1957	21	52	150
1958	26	66	195
1959	24	145	330
1960	26	216	239
1961	27	53	39
1962	19	57	50
1963	21	62	27
1964	16	93	28
1965	31	182	77
Average	23.7	164.6	272.7

trol and quarantine measures have accounted for the decreased incidence among domestic dog populations. Reasons for the increase among wildlife species are not so clear.

Whatever the causes, involvement of foxes as a vector resulted in a rapid spread of rabies across the State. Six years after the start of the 1945 epizootic among foxes, the disease had spread in that species to 29

of the State's 57 non-urban counties. Two counties were involved during 1945, an additional six in 1946, nine more in 1947, five in 1948, four in 1949 and the remaining three in 1950 (Figure 2). Subsequent involvement of the skunk and bat has sustained a high number of counties in which rabies has been present each year, even though the annual total number of cases may have been relatively low.

The influence of wildlife species on the yearly distribution of rabies in the State may be illustrated by comparing data for the period before 1944, the year wildlife as vectors became important, with data for subsequent years (Table 5). During 1939 there were 155 cases reported, 154 of which were in dogs. No wildlife cases were reported and only 10 counties were involved. During 1961 the reported incidence was 92 cases, a 28 per cent decrease from 1939, and only four were in dogs, a decrease of over 95 per cent. However, 53 cases occurred among wildlife species, and rabies was reported in a total of 27 counties. This represented a 170 per cent increase in the number of counties in which rabies occurred.

Involvement of wildlife may be considered as falling in three categories: primary vector species, secondary vector species and occasionally infected species.

Primary Vector Species

Primary vector species are those which account for the main source of infection in various areas. In New York these are the red fox, gray fox and striped skunk. Incidence among these has been sufficiently high in local areas to cause population control efforts to be undertaken.

Fox There are two species of fox in New York, both of which have been found positive for rabies. The red fox (*Vulpes fulva*) is more common than is the gray fox (*Urocyon cinereoargenteus*). At times both occur in high densities in various areas of the State. They have usually been lumped together in rabies records throughout the years, so that it is impossible to determine the role each has played in perpetuating the the disease. However, Parker *et al.* (1957) found that the ratio between reported cases of rabies in the two species was about the same as the ratio between the two species among specimens taken during a trapping program designed to evaluate the relationship of fox densities to rabies.

The red fox is by far the more common species in the State. The actual ratio between it and the gray fox is unknown and is subject to considerable area variation (depending upon habitat and the occurrence of sarcoptic mange). Linhart (1960) noted that trapping records indicated a ratio of nine adult red foxes to one adult gray fox for some areas of the State. This is probably high for the State as a whole, because gray fox habitat is increasing as more and more abandoned farmland reverts to brush and woodland.

Since 1944 the fox has been the most important wildlife vector of

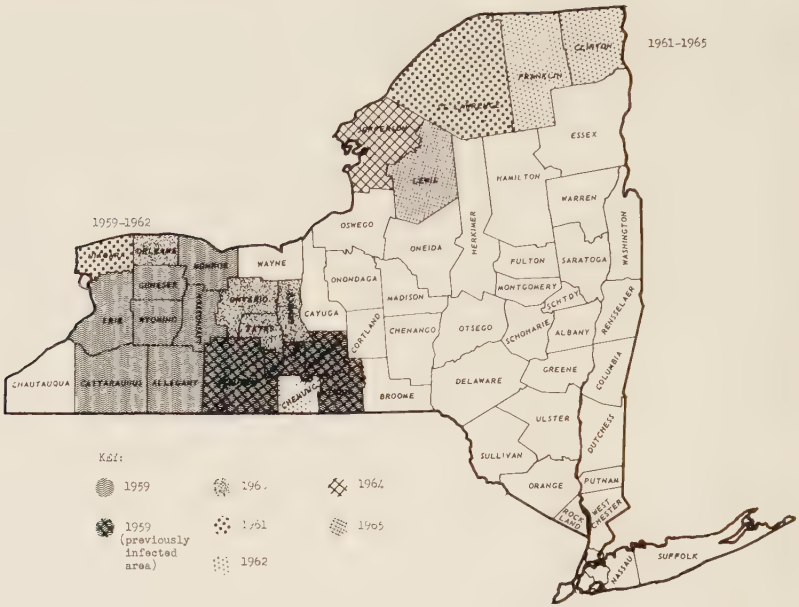

Figure 3. Spread of rabies among foxes, by county and year, during two outbreaks in New York State.

rabies in the State. Its role was well illustrated in the major epizootic of 1945 and in the lesser outbreaks of 1959 and 1961 (Figures 2 and 3). It has withstood concentrated reduction campaigns and the effects of diseases such as mange, canine distemper, infectious hepatitis and leptospirosis, as well as the ravages of rabies itself.

Rabies incidence among foxes has shown a seasonal variation associated with fox movement. The greatest number of cases have occurred in March and April with a lesser peak occurring in October. The primary peak reflects exposure when the foxes were pairing and mating during late January and early February. The secondary peak coincided with the dispersal of family groups and extension of individual range (Linhart, 1960).

In addition to the seasonal variations, periodic fluctuations of rabies in foxes seem to have occurred at 5-year intervals. This was reflected in the total wildlife and domestic animal cases (Figure 4). There was a close correlation between the number of cases in cattle and those in foxes (Linhart, 1960). This correlation is illustrated by comparing the total indemnities paid for rabies claims with the total number of fox cases reported from year to year (Figure 5). This is not to imply that all claims were the result of fox-transmitted rabies, but the correlation does suggest that foxes played an important role in the transmission of rabies to domestic livestock.

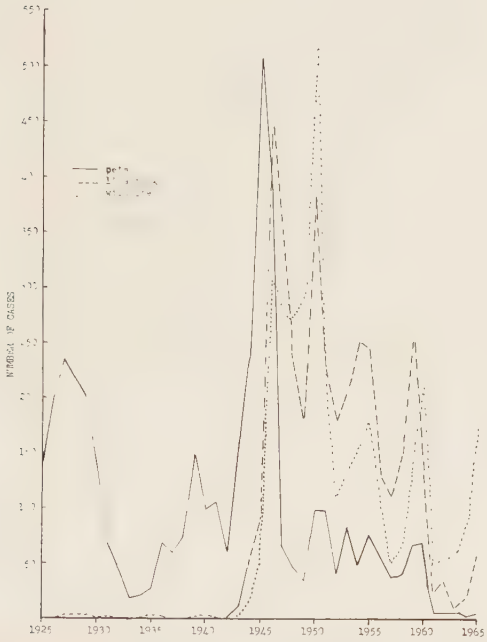

Figure 4. Reported incidence of rabies in pets, livestock and wildlife in New York State (exclusive of New York City) from 1925 to 1965.

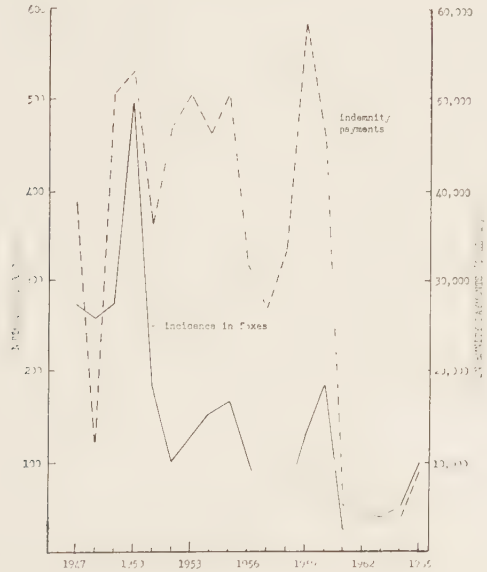

Figure 5. Relationship between incidence of rabies in foxes and livestock indemnity payments in New York State (exclusive of New York City) from 1947 to 1965.

Skunk In 1948 rabies infection among skunks (*Mephitis mephitis*) reappeared, after a 10-year period of no reported incidence, when two cases were reported, one each in Chemung and Tompkins Counties. These counties are west of Broome County where the epizootic in foxes occurred. Occasional incidence among skunks continued to be reported over the next 11 years and appeared to follow the general spread of the disease in the State (Figure 6).

In 1959 and 1960 a total of 23 skunks were found to be positive for rabies, which equalled the total number found positive for the State as a whole prior to 1959. Most of these cases were associated with a rabies outbreak among foxes in the Wyoming, Erie and Genessee County area. The statewide total of 17 cases in 1960 represented a nearly threefold increase over the previous high of six cases in one year as reported in 1950 and 1959.

Since 1960, and especially since 1963, this species has taken on new importance as a vector of rabies in the State (Figure 7). Unlike the fox, the skunk has not been studied extensively, and relatively little is known about its general ecology, distribution and population in the State. Even less is known about its association with rabies despite the fact that the first three reported wildlife cases in the State (in 1929, 1934 and 1937) were all in skunks. The lack of interest in this species, until now, is reflected in Table 6 which shows that from 1946 to 1963 only 210 skunks were submitted for rabies examination. It was not until 1959 that as many as 20 skunks were submitted in a single year. As with other species the number of specimens submitted reflects local interest and the amount of rabies present in the area. Generally, the more skunks submitted, the greater the number of positive cases reported. The incidence among the 210 skunks examined during this period was approximately 33 per cent.

Friend (1966) found 2 of 22 skunks from Saratoga County and 0 of 119 collected from four other counties (Albany, Chautauqua, Delaware and Jefferson) to be positive for rabies during a survey of wildlife vector species during the period from April to October in 1965. Most of these specimens were steel trapped, but the two positive skunks were found wandering about. Rabies in skunks is considered to have been enzootic in Saratoga County. Among all skunks collected in any of the other four counties the greatest incidence in recent years was three, all in Jefferson County (two in 1964 and one in 1965); also two rabid skunks were taken in this county during the first six months of 1966.

The greatest numbers of positive skunks were reported from Clinton County and Erie County at opposite ends of the State. Total incidence in either county was less than 40 cases, and few counties have reported as many as 10 cases since 1929 (Figure 8). The total reported incidence

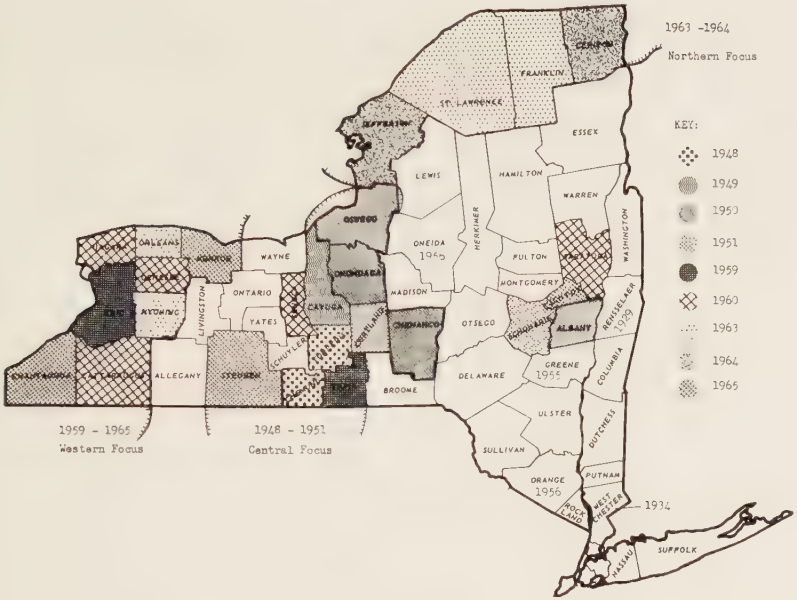

Figure 6. Spread of rabies among skunks, by county and year, in New York State (exclusive of New York City) from 1929 to 1965. For Greene, Oneida, Orange, Rensselaer and Westchester Counties, dates shown represent year of first reported case in county.

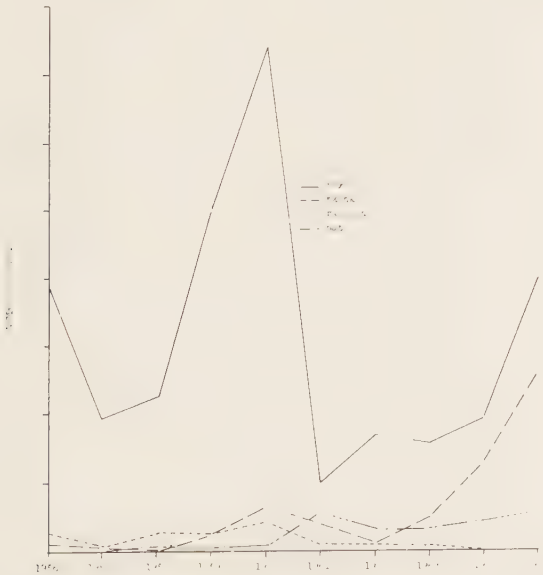

Figure 7. Reported incidence of rabies in four wildlife species in New York State (exclusive of New York City) from 1946 to 1965.

Table 6. Incidence of Rabies in Specimens of Five Wildlife Species from New York State, Exclusive of New York City, Submitted to the State Department of Health for Diagnosis from 1946 to 1963

Item	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Total
Fox																			
Number examined	379	409	412	433	702	314	280	301	314	298	224	143	169	300	300	185	200	119	5,482
Positive																			
Number	309	275	258	278	497	183	101	129	155	168	99	49	56	127	186	25	43	40	2,978
Per cent	81.5	67.2	62.6	64.2	70.8	58.3	36.1	42.8	49.4	56.4	44.2	34.3	33.1	42.3	62.0	13.5	21.5	33.6	54.3
Skunk																			
Number examined	1	0	8	11	9	9	4	7	3	5	10	11	13	20	31	24	12	32	210
Positive																			
Number	0	0	2	1	6	3	0	1	1	2	3	1	0	6	17	11	3	12	69
Per cent	0.0	0.0	25.0	9.1	66.7	33.3	0.0	14.3	33.3	40.0	30.0	9.1	0.0	30.0	54.8	45.8	25.0	37.5	32.9
Raccoon																			
Number examined	17	22	43	50	138	93	65	93	100	126	109	74	77	139	133	91	97	65	1,523
Positive																			
Number	11	6	18	16	28	20	11	5	9	15	7	2	7	6	11	3	2	2	179
Per cent	64.7	27.3	41.9	32.0	20.3	21.5	16.9	5.4	9.0	11.9	6.4	2.7	9.1	4.6	8.3	3.3	2.1	3.1	11.8
Bat																			
Number examined	0	0	0	0	0	0	0	0	2	0	2	7	8	52	48	252	195	87	654
Positive																			
Number	0	0	0	0	0	0	0	0	0	0	1	0	2	1	2	14	8	8	36
Per cent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	25.0	1.9	4.2	5.6	4.1	9.2	5.5
Opossum																			
Number examined	0	1	2	5	13	3	1	1	3	8	2	1	2	9	3	4	0	5	63
Positive																			
Number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Per cent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

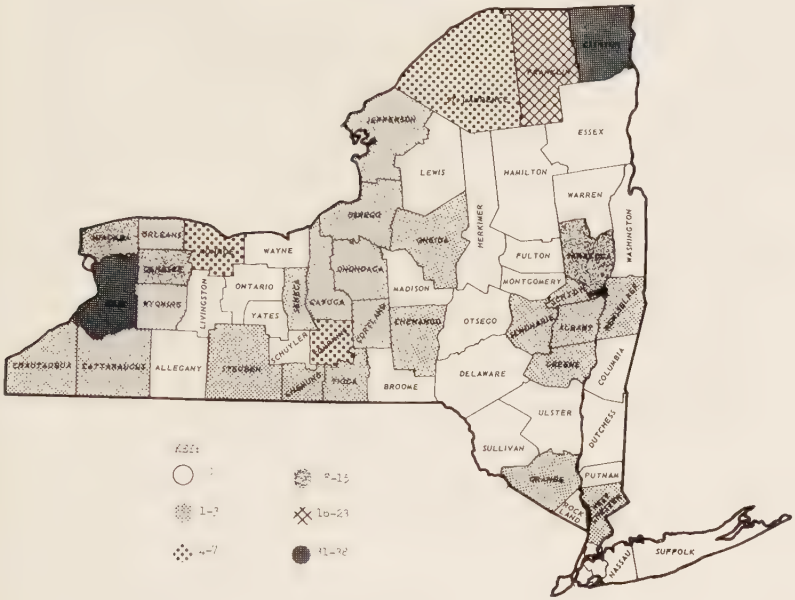

Figure 8. Distribution of total reported cases of rabies among skunks in New York State (exclusive of New York City) from 1929 to 1965.

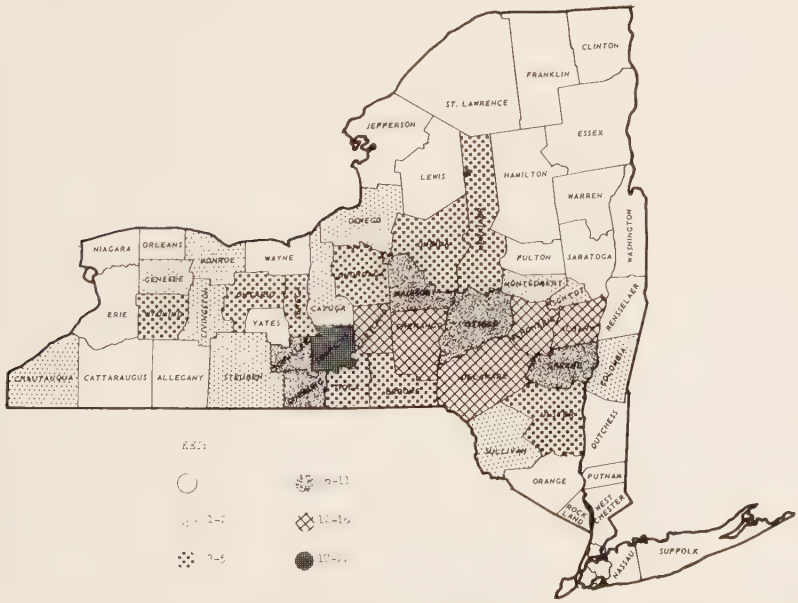

Figure 9. Distribution of total reported cases of rabies among raccoons in New York State (exclusive of New York City) from 1944 to 1965.

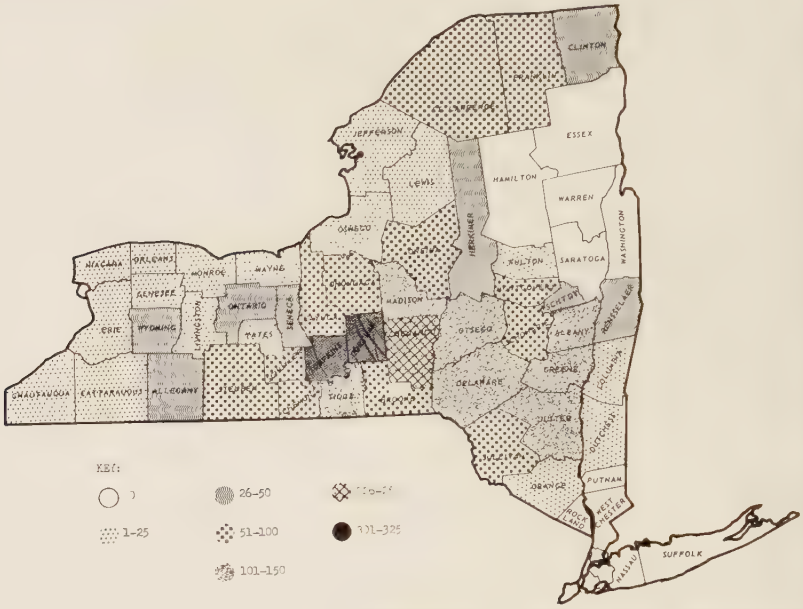

Figure 10. Distribution of total reported cases of rabies among foxes in New York State (exclusive of New York City) from 1941 to 1965.

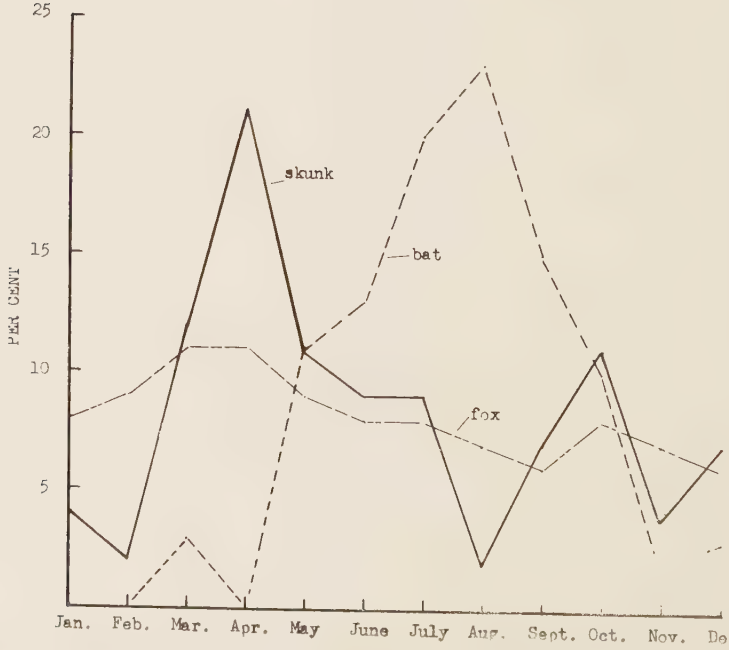

Figure 11. Monthly incidence of rabies among wildlife vectors in New York State (exclusive of New York City) from 1929 to 1965.

for skunks closely parallelled that found among raccoons (Figure 9), but both were far below that reported among foxes (Figure 10). In 1966 rabies among skunks appeared to be enzootic in Saratoga County, sporadic in the central and eastern regions of the State and active in areas where rather recent outbreaks had occurred. The most recent of these was in the north along the St. Lawrence River valley and the other in eight counties in the western part of the State (Figure 6).

Limited data are available on seasonal fluctuations of rabies in skunks in the State because of the low number of animals involved. The peak of reported incidence among striped skunks in the Midwest usually occurs in April or May (Sanderson and Alberts, 1963). Peaks in Ohio are reached during the period of mid-March to mid-May (Schnurrenberger *et al.*, 1964). Present data indicate April to be the month of highest incidence in New York with secondary peaks occurring in June and October (Figure 11). This pattern of infection closely follows that occurring in the fox in this State.

Secondary Vector Species

Bats and the raccoon make up the second group. Despite high populations, rabies infection among these animals has usually been characterized by a low number of widely scattered cases from year to year and an existing rabies infection among other species in the area. At times bats have represented the only cases from an otherwise rabies-free area.

Raccoon The first reported positive case of rabies in a raccoon (*Procyon lotor*) was diagnosed from Chautauqua County in 1944 and was associated with the outbreak among foxes in the county at that time. Two years later, during the epizootic in Broome County, 11 positive cases among raccoons were recorded; five occurred in each of the counties of Cortland and Chenango, to the north of Broome. At no time during this epizootic did the raccoon ever become a major contributing species in the spread of rabies. Reported incidence ranged from a high of 28 cases in 1950 to no reported cases during 1945, 1964 and 1965. Since 1952 the reported annual incidence has been less than 10 except for two years, i.e., 1955 with 15 cases and 1960 with 11 (Table 3). Distribution of these cases was widespread with the greatest number occurring in the central part of the State (Figure 9).

High densities of raccoons have frequently occurred in the State, and just as commonly outbreaks of disease have reduced these populations to lower levels. Diseases such as rabies, leptospirosis and mange have been involved, but distemper appears to have been the most important disease controlling raccoon density. High raccoon populations have often occurred concurrently with rabies outbreaks among other species, yet the number of rabid raccoons recorded has been small. What role the raccoon

may play in the general ecology of rabies in the State is unknown, but it is assumed at present that it is not important in rabies transmission.

Like the skunk, the raccoon has not been studied in its relationship to rabies in New York. During the period from 1946 to 1963 approximately half as many raccoons as foxes were submitted annually because of peculiar actions or, in rare instances, because they bit someone. The proportion of rabid raccoons always fell below that of foxes, and since 1953 it has been less than 10 per cent except for 1955 (11.9 per cent). This reflects the presence of distemper which was often diagnosed from the animals submitted and frequently caused the symptoms leading to their collection and submission.

Rabies infection among raccoons in New York has followed local outbreaks of the disease in other species. This species might even be considered as a good barometer of the scope of infection among wildlife populations, since its involvement appears to be limited to the more severe outbreaks. The greatest number of cases has occurred in the south-central part of the State in an area bounded by the Hudson River on the east, the Mohawk River on the north and the Finger Lakes on the west (Figure 9).

Bat A variety of bats inhabit New York State, including six species from which rabies has been isolated in one or more other states. These include the big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*) and eastern pipistrelle (*Pipistrellus subflavous*), all of which are colonial types. The others belong to the group of so-called solitary or tree bats and include the silver-haired bat (*Lasionycteris noctivagans*), the hoary bat (*Lasiurus cinereus*) and the red bat (*Lasiurus borealis*). In New York little effort has been made to identify rabid bats. The only positive specimens to have been definitely identified by species are the big brown bat and little brown bat.

Rabies in bats was first reported in the State in 1956 when one case occurred in Rensselaer County. Between then and December 31, 1965 an additional 60 positive cases were reported, 55 of them since December 31, 1960 (Table 3). The greatest number of cases (seven) was from Nassau County on Long Island. Of 27 counties that have reported rabies in bats, 14 have reported single cases and six others only two cases each (Figure 12).

The spread of rabies in bats has been unlike that which has occurred among other animals. However, this might be expected due to their highly mobile character and the migratory nature of the species involved. The greatest spread occurred in 1961 when 10 new counties were added to the list of those having rabies in bats despite the fact that only 14 cases in bats were recorded for the entire State in that year. The pattern of spread was in the form of a "T" formed by the Hudson River from

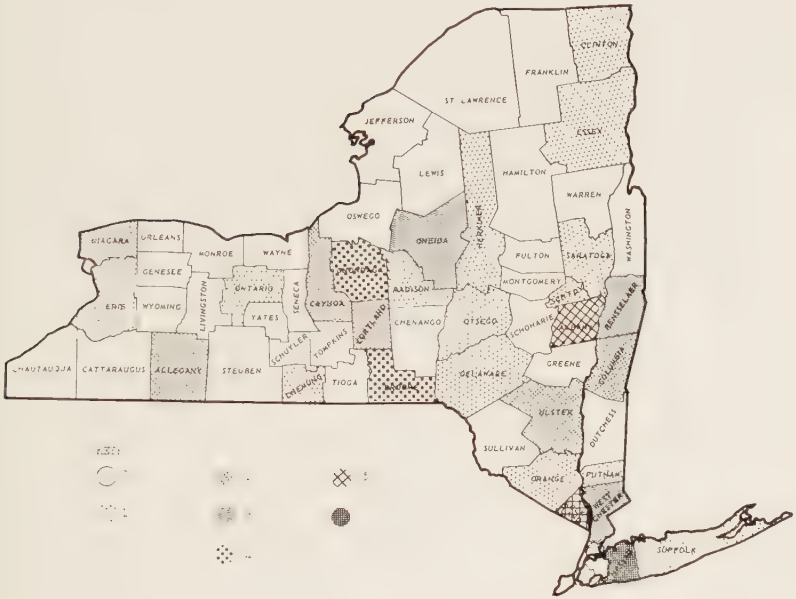

Figure 12. Distribution of total reported cases of rabies among bats in New York State (exclusive of New York City) from 1956 to 1965.

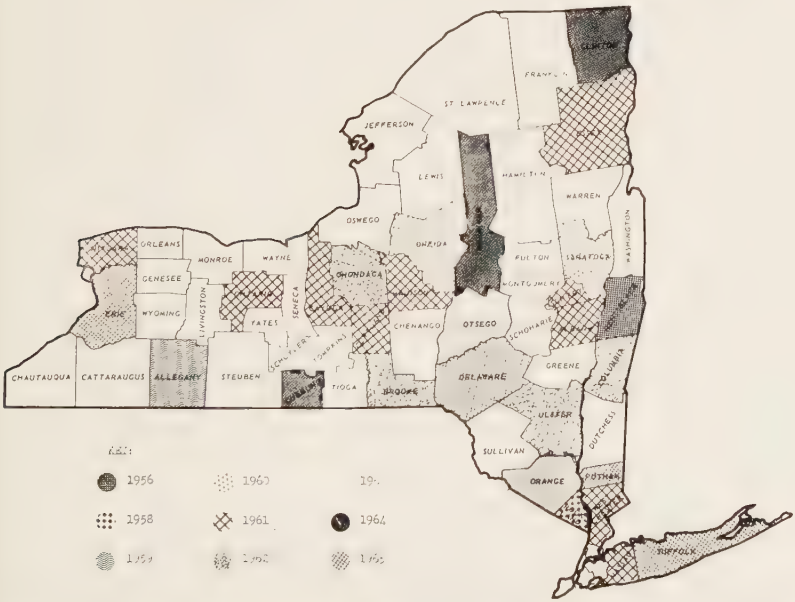

Figure 13. Spread of rabies among bats in New York State (exclusive of New York City), by county and year, from 1956 to 1965.

north to south and the Mohawk River from east to west. Counties reporting rabies in bats during that year were as far removed as Niagara County in the west, Essex County in the northeast and Nassau County in the south (Figure 13).

Rabies in bats appears to have been entirely independent of rabies in other species in the State. It has occurred in areas that have had no other reported rabies cases for years, as well as in areas where active infection is or has been prevalent among other species. At present it is recognized as a potential problem but is not considered serious.

Unlike that for other wildlife vectors, the peak of rabies incidence among bats in New York has occurred in late summer rather than in the spring. The limited data available show the highest peak to have been reached during August. Nearly all cases were reported from May through October, and none was reported in January, February or April (Figure 11).

The late summer peak of incidence among bats is not surprising as this is a period of considerable movement. In neighboring New England, Hitchcock (1965) noted that the little brown bat does considerable wandering during the middle and latter part of the summer in addition to migrations between its summer area and winter quarters. The autumnal movement of solitary bats, such as the red bat, hoary bat and silver-haired bat, takes place from mid-August to November in the Northeast, apparently peaking in early September (Allen, 1939). The absence of reported incidence for April could reflect sample size, or it might indicate an incubation period of the virus within the species. In New York, April or May is usually the earliest month when temperatures rise sufficiently to allow bats to leave their winter retreats and begin summer activities. Associated with this period is the emergence of flying insects, the food supply of bats.

A relatively large number of bats were examined for each positive specimen diagnosed (Table 6). This would indicate that rabies infection among the population sampled was at a low level. A survey of 520 bats collected in New England during 1962-63 revealed a similarly low incidence of positive case (1.54 per cent) but showed significant differences among infection rates between the species examined (Girard *et al.*, 1965). In their study only 0.76 per cent of the little brown bats were found to be infected with rabies while the incidence among big brown bats was 4.10 per cent.

Occasionally Infected Species

Over the years rabies has been diagnosed in several other species in the State (Table 3). This is probably only a small part of those actually involved. Such cases seldom, if ever, reflect active infection in the species, but arise from contact with other rabid animals such as the fox, skunk,

domestic dog and even the domestic cat. Of passing interest is the fact that eight white-tailed deer (*Odocoileus virginianus*) were found to be positive for rabies during the period from 1948 to 1959.

TRENDS IN INCIDENCE

The incidence of rabies in New York has shown periodic fluctuations with peaks every four to five years since 1946 (Figure 14). These peaks generally coincided with highs in fox populations. The influence of foxes, and more recently the skunk, as vectors is seen also in the seasonal fluctuations of the disease.

April, August and October, in that order, were the peak months of incidence; however, the disease occurred during all months of the year. Prior to noticeable wildlife involvement, the peak of incidence occurred during March, April and May and the least number of cases was reported from August to October (Figure 15). The present peak months coincide with periods of maximum movement and dispersal among the major wildlife vector species. Peculiarly, the greatest number of cases in domestic animals coincided with the secondary peak for wildlife in October, while a low number occurred at the time of the maximum peak for wildlife in April. For the period from 1946 to 1965, the incidence in cattle exceeded that in foxes from July through December, while the reverse was true for the remaining months (Figure 16).

The low number of cattle with rabies during the early spring is not surprising when the incubation period of 1 to 2 months or more is considered. Cattle are generally confined to the barn during the winter and are not turned out to pasture until April or May in many parts of the State. Exposure to rabies before this period is unlikely.

DISCUSSION

Rabies, like other diseases, is dependent upon susceptible hosts for its spread. Usually, the greater the number of susceptible animals in a given area, the more dynamic the outbreak. In New York the high populations of susceptible foxes present in the early 1940's were ideal for the explosive outbreak that began in 1945. However, low fox populations play their role also, as they have been found capable of sustaining an enzootic of the disease (Parker *et al.*, 1957). Areas such as Chautauqua County have had a sustained rabies infection in a small number of foxes in the midst of a peak population, only to have the disease appear to die out with no further spread. There is no apparent explanation for the fact that rabies persists among foxes in some areas of low population density, while foxes in other areas of high population density are apparently unaffected by the disease despite its occurrence in other species.

The assumption has been made that in New York certain ecologic barriers must exist which apparently limit the spread of rabies (Parker

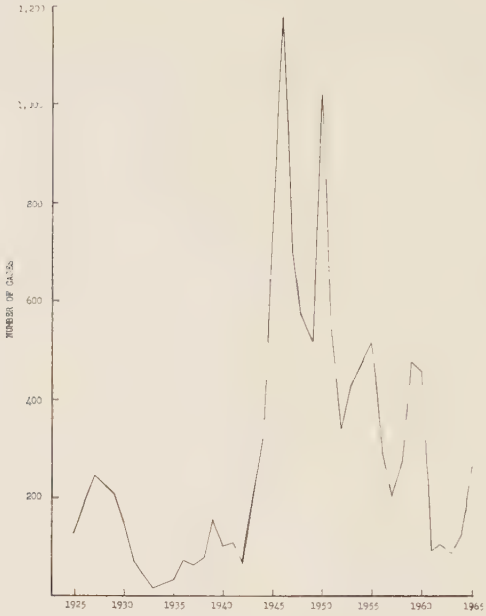

Figure 14. Annual reported incidence of rabies in New York State (exclusive of New York City) from 1925 to 1965.

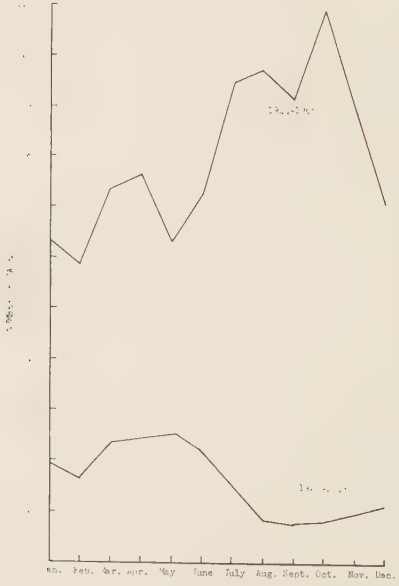

Figure 15. Monthly incidence of rabies in New York State (exclusive of New York City) before (1927-1943) and since (1944-1965) wildlife involvement.

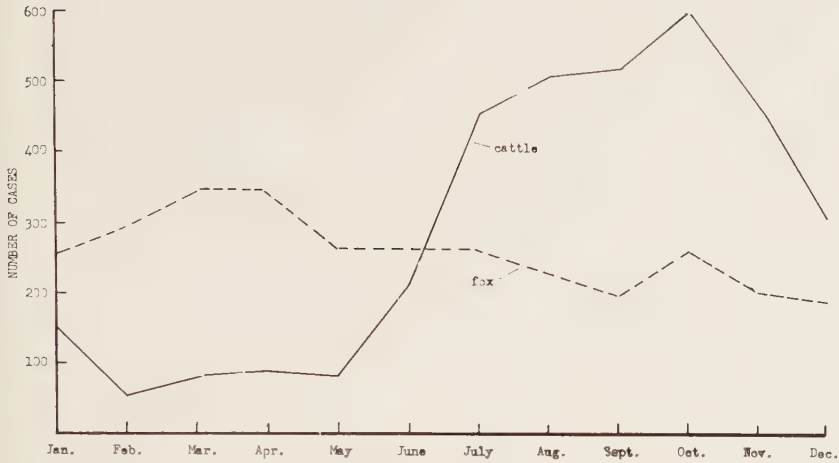

Figure 16. Monthly incidence of rabies among cattle and foxes in New York State (exclusive of New York City) from 1946 to 1965.

et al., 1957). Rivers, lakes, mountain ridges and deep snow were natural barriers listed by Dean and Albrecht (1959) as having some influence in limiting the spread of the disease in the State. However, other factors also are obviously involved. How else does one explain the lack of rabies among foxes in Saratoga County despite fairly high fox populations and its presence in other species such as the skunk? Also, there is no ready explanation for shifts of infection from one species to another, such as occurred in Erie County where an outbreak in 1959-60 involved a number of foxes and a much smaller number of skunks. Yet, following a 3-year period when no cases were reported, rabies again broke out in 1964 and 1965 when 21 rabid skunks and a rabid bat were reported, but only a single fox case. This change in the important vector species was also evident in the recent outbreak in the area along the St. Lawrence River. At its onset, this outbreak appeared to be among foxes primarily in all four counties and to a lesser degree in skunks. But Clinton County proved to be an exception to this pattern. After two years during which rabies was reported only in foxes, a nearly equal number of skunk cases occurred in 1964 (15 skunks and 17 foxes). The following year only two fox cases and 21 skunk cases were diagnosed. This trend continued to the point where for the first six months of 1966 eight skunk cases and no fox cases occurred in this county (Table 7).

The possibility exists that these situations reflect availability of susceptible animals, and that, after reducing population levels in one species, the disease attacks a more abundant host. Another consideration is that rabies outbreaks among foxes and skunks are completely independent of one another. This appears to have happened in at least one area in Illinois (Sanderson and Alberts, 1964). In this connection, it is

Table 7. Reported Incidence of Rabies among Wildlife Species by County in the St. Lawrence River Region from 1961 to 1966

County and species	1961	1962	1963	1964	1965	1966*
St. Lawrence						
Fox	8	10	8	9	54	19
Skunk	0	0	1	3	3	4
Franklin						
Fox	0	11	9	14	18	3
Skunk	0	0	6	8	4	5
Fisher	0	0	0	0	1	0
Clinton						
Fox	0	6	10	17	2	0
Skunk	0	0	0	15	21	8
Bat	0	0	0	1	0	0
Jefferson						
Fox	0	0	0	5	13	47
Skunk	0	0	0	2	1	2
Raccoon	0	0	0	0	0	3
Opossum	0	0	0	0	0	1

* Through June 30.

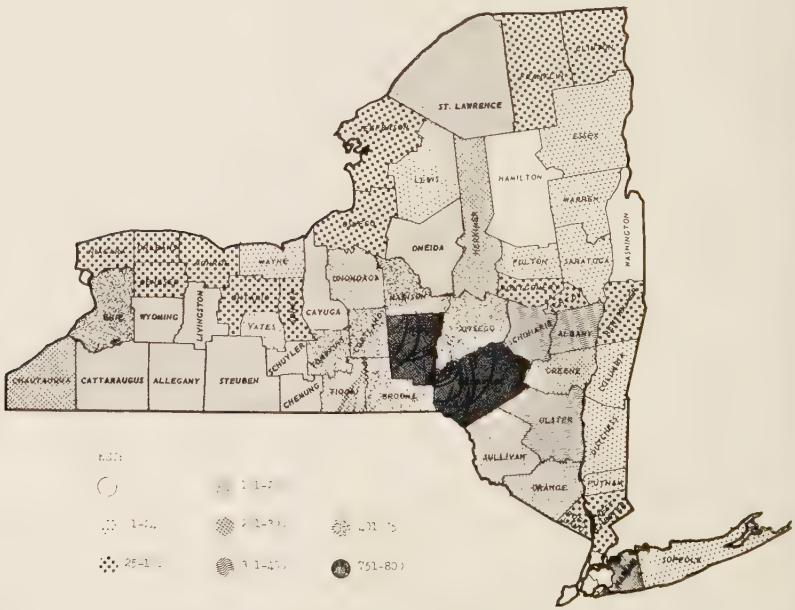

Figure 17. Distribution of total reported cases of rabies in animals (wild and domestic) and humans in New York State (exclusive of New York City) from 1940 to 1965.

interesting that in two of the 10 counties in New York in which rabies has not occurred in foxes it has occurred in skunks (Figures 8 and 10).

Rabies has been a problem in New York for many years. It has varied in intensity from year to year and from one area to another. The southcentral part of the State has been hardest hit in total number of cases (Figure 17). Current outbreaks in the northern and western counties have shifted attention to those areas. Changes in vector species have also occurred along with the focal points of infection. The problem has shifted from one involving a domestic vector, the dog, to one involving a number of wildlife vectors. Control of these vectors is not as simple or as efficient as instituting dog vaccination programs. In an effort to curb the disease, however, New York carries on one of the most intensive wildlife control programs in the nation (Linhart, 1960) and is actively engaged in research which, hopefully, will lead to better control methods.

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CONTROL OF RABIES IN WILDLIFE IN NEW YORK

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ABSTRACT

Three programs are being carried on in New York to control the spread of rabies in wildlife. The most effective is that of fox trapping by State trappers administered by the Conservation Department. Trapping by county employees has been of limited value, and bounty payments by counties have been ineffective. Operation of the State program is described, and other control methods are discussed.

Research concerning a chemical reproduction inhibitor that might be used to control fox abundance indicated diethylstilbestrol (DES) to be effective on female foxes and to be the most promising. Because of unrelated factors, however, a field test was inconclusive. Achromycin proved satisfactory as an additive to baits for physiologically marking animals that ate them.

Efforts to control rabies in wildlife in New York State involve several agencies. Advice and direction is afforded by the Interdepartmental Rabies Committee which consists of representatives from each of the four State departments concerned with the problem, namely, the Departments of Agriculture and Markets, Conservation, Education, and Health. Committee members include field personnel as well as administrators. Meetings are held at least twice a year and more frequently when the situation warrants. Among the functions of this committee are the coordination of rabies control activities, dissemination of information relating to the disease within the State, determination of areas to be trapped under the State control program and guidance of research to develop more efficient control methods.

CONTROL PROGRAMS

At present there are three programs specifically aimed at controlling the spread of rabies in wildlife. The most effective of these is that administered by the Conservation Department. County trapping supervised by the Conservation Department and county bounty systems constitute the other two.

State Program

In 1946 several trappers were employed specifically to control rabies in wildlife, with emphasis on fox population reduction. One of the Conservation Department's regional game managers supervised the trappers in addition to his other activities. In 1948, when the interdepartmental committee was organized, a full-time coordinator was employed to supervise the State program. From 1948 to 1960, 20 to 24 trappers were employed on a seasonal basis each year. This period usually ran

from April to December, but, if winter snows permitted, some men were retained a month or two longer to trap in problem areas. However, winter trapping was generally found to be impractical because of continual low temperatures and other adverse weather conditions. Since 1960 the program has been carried on with three supervising trappers, five permanent full-time trappers and from six to ten seasonal trappers. The supervising and permanent trappers are assigned to census certain areas or to conduct field research during the winter.

Generally the trapping is conducted on a trapper-per-township-per-month basis with trappers working continuously for 20 to 22 days each month and taking accumulated leave at the end of that time. In most townships this period of trapping has been sufficient to reduce the fox density to a desirable level.

Trapping Methods and Control Procedure The standard fox set used by all program trappers is the dirt hole set. Individual trappers have their own peculiar variations, but the results by experienced men have been essentially good. Set locations vary according to the judgment and experience of the trapper as well as the season of the year.

During the spring, trappers usually seek out den locations and saturate the area with traps, many times taking several pups in addition to adult foxes in one night. This procedure is effective because the cruising radius of a fox at this season is generally limited to within ½ mile of its den site.

Fall trapping is much different because fox litters have dispersed from denning areas, and the young are establishing new home ranges. Studies in central New York have shown that red foxes may travel 40 miles or more in the course of what is commonly called the "fall shuffle" (Sheldon, 1950). Trappers who find a good fall travel route may catch 10 or 15 foxes in one set in as many days.

Early in the program, the usual procedure in attempting to control the spread of rabies infection was to trap in a 5- to 10-mile zone around the periphery of the infected area. This was soon found to be inadequate, and zones 15 to 18 miles wide proved to be more effective. The theory of zone-type trapping was to reduce fox populations to a level where there would be little or no chance for rabid animals from the infected area to contact susceptible foxes outside. Thus, the chain of transmission would be broken.

This procedure was used in an effort to contain the rabies epizootic in foxes which occurred in Broome County during the mid- and late 1940's. Nevertheless, the infection spread continually in all directions. Although the trapping done did not halt the spread of the disease, it is felt that the population reduction achieved decreased the number of cases which would otherwise have occurred.

Since then, rabies in wildlife has occurred throughout most of the State and is apparently endemic in many areas. This has led to a change in control procedures in recent years. Current operations are based on periodic estimates of fox density obtained from winter roadside track censuses in particularly good fox range. These estimates indicate the location of potential rabies epizootic areas. Trapping is then conducted in these areas during the next trapping season in an attempt to reduce the densities of fox and other potential wildlife vector populations to a "safe" level. Townships having high fox densities within or adjacent to areas where rabies is endemic receive primary trapping attention.

Just what fox population density constitutes a safe level with respect to the danger of a rabies epizootic is difficult to determine. Theoretically, a density of three foxes per square mile would be hazardous, whereas a density of one fox or less per square mile would be safe. Reduction to the latter level can be achieved by control trapping.

Unfortunately the success of this type of control is practically immeasurable. Rabies is already present in many areas being trapped, and cases continue to occur in these areas. Whether or not the incidence is significantly lessened by reducing the density of vector populations is only speculation. The fact that recent rabies outbreaks in the State have not reached the epizootic proportions experienced 15 to 20 years ago may indicate some degree of successful control.

The catch of foxes and skunks by State trappers each year from 1958 to 1965 (Table 1) shows that a substantial number of potential rabies vectors were removed annually under this program. The incidence of rabies in these species for the same years is also shown. There was no

Table 1. Annual Catch of Foxes and Skunks by State Trappers and Incidence of Rabies, 1958–1965

Year	Trapper months*	Fox			Skunk	
		Number caught	Trap nights per fox§	Incidence of rabies	Number caught	Incidence of rabies
1958	156	3,200	28.0	56	1,478	0
1959	161	3,141	29.4	127	1,239	6
1960	122	2,067	33.7	186	1,135	17
1961	89	2,026	23.9	25	884	11
1962	89	1,576	33.7	43	755	3
1963	68	1,702	23.7	40	689	12
1964	69	1,595	23.6	49	1,063	33
1965	86	1,840	21.5	100	611	66

* A trapper month represents one trapper working an average of 20 days during one month.

§ A trap night represents one trap set in operating condition for one night.

apparent correlation between trap nights per fox caught and the incidence of rabies in foxes. The yearly differences in trap nights per fox caught probably indicate differences in trapping efficiency rather than reliable variations in fox density.

COST At present (1966) the average cost for each fox taken by State trappers is between $25 and $26 which is about the same as that cited by Linhart (1960). While this may seem high, one must realize that, in order to reduce a population to the desired level, a trapper must remain in his assigned area until he is catching very few animals per number of traps in his line. Thus, the average cost per animal is increased considerably during the last few days of trapping. Furthermore, capturing other rabies vector species, such as skunk and raccoon, contributes to the over-all control effort, but no reduction in cost per fox caught has been credited because of this. In some areas removal of the secondary vector may be more beneficial to rabies control than reduction of foxes alone.

CENSUS METHODS Trapping operations under the State program are currently dependent on the location of high-density fox populations. The most extensively used census method is a modification of the roadside track count described by Scott (1941). A fair estimate of comparative fox density over a particular area may be derived by establishing a road route of 20 to 30 miles through typical fox range and counting the fox tracks crossing it after each of several fresh snowfalls. If the route is maintained and checked annually each winter, fluctuations in fox density can be determined.

Another census technique used is a modification of the scent post method described by Cook (1949). A map of the area to be censused is gridded in square-mile units. Half the total units are randomly selected as units in which to locate one scent post. A scent post is very similar to a dirt hole trap set without the trap and on the edge of a 2-foot cleared space covered with lightly sifted dirt from which the tracks of visiting animals may be easily read. Fox density is determined on the basis of number of visits over a five-night period; the lower the number of nights per visit, the higher the density. This technique is used to determine comparative fox densities for field study purposes.

Parker *et al.* (1957) simultaneously trapped foxes in several townships for a 10-day period in the fall to determine the relative population densities and expressed the resulting indices in terms of trap nights per fox taken. Although this method gives good indices, it is impractical under the present control procedure because it would necessitate diverting an extensive trapper force at a time of year when control trapping is most productive.

Fairly reliable estimates of fox density are obtained by using winter roadside track counts together with appraisals by the experienced pro-

fessional trappers conducting these track counts. This gives a sufficiently adequate measure of yearly fluctuations to allow planning annual control trapping in the various counties. However, no practical, highly accurate census technique is available for detecting fluctuations among fox populations.

County Programs

Counties which have been certified as being in a rabies-existent area by the State Health Department are eligible for State aid to operate a control trapping program. The usual procedure is for a county board of supervisors to make an appropriation for employing rabies control trappers. Then 50 per cent of the money expended (but not more than $6,000 in one county in a given year) may be reimbursed by the State. Supervision of county trappers is furnished either by personnel of the State program or by regional game management personnel.

Most county programs have not been begun until after the presence of rabies has become evident and thus have been relatively ineffective. However, some counties have continued seasonal programs for several years, and apparently have maintained a reduced level of fox density. The catch from 1961 to 1965 is shown in Table 2. The number of trap nights per fox caught was noticeably higher for county trappers than State trappers (Table 1). This is partially explained by the fact that the county men must trap within the county throughout their employment. Often they will retrap areas and have very little success, but retrapping is necessary to reduce fox density to the desired low level. This greatly increases the average number of trap nights per animal taken.

From 1961 to 1965 the average cost to the State for each fox caught by county trappers was between $14 and $15. However, adding in the county's share brings the amount to from $28 to $30, or slightly higher than that for trappers under the State program.

Table 2. Annual Catch of Foxes and Skunks by County Trappers, 1961–1965

Year	Number of counties	Number of trappers	Fox		Number of skunks caught*
			Number caught	Trap nights per fox	
1961	4	10	1,152	37.2	..
1962	5	11	934	38.4	..
1963	5	9	813	37.4	..
1964	4	7	713	41.2	545
1965	4	6	924	32.6	522

* No data available until 1964.

OTHER CONTROL METHODS

Three other control methods that have been tried or suggested may be commented on.

BOUNTIES Several counties sponsor fox bounties, but the evidence indicates this to be an ineffective method of reducing fox density. Many times, catches by State trappers have been higher in bounty counties than in comparable non-bounty counties. Fox bounties are no incentive for reducing other rabies vector species which are removed along with foxes under the State and county trapping programs.

DISEASE Disease may produce a natural control in some high-density fox populations. Sarcoptic mange, which became quite prevalent in New York in the late 1940's, effectively reduced red fox abundance to the point where entire areas seemed to be void of the species. The gray fox is apparently unaffected by this disease. Rabies itself can decimate a population until its density reaches a very low level. Distemper and other encephalitic diseases also may play a role of some importance as natural limiting factors with respect to fox populations.

HUNTING AND TRAPPING BY SPORTSMEN Sportsmen also have contributed to fox populations control in some areas of the State. The Department's small game take survey for 1964-65 and 1965-66 showed that over 40,000 fox hunters took more than 47,000 foxes each year (Table 3). In 1965, the fur market reflected a good demand for red

TABLE 3. FOXES TAKEN BY HUNTERS DURING 1964–65 AND 1965–66

Season	Number of hunters	Days afield	Number of foxes taken
1964–65	40,682	238,311	47,563
1965–66	42,017	247,293	48,227

fox, with prices as high as $12 per pelt reported to have been paid. If such a demand should continue, it should result in a noticeable effect on fox abundance in areas having avid fox hunters and trappers.

RESEARCH

As the rabies control program was continued into the 1950's, the administrative costs were recognized as comparatively high for the results achieved. Various proposals were considered in a search for methods of reducing fox populations that would be more economical than trapping. Primary investigations from 1955 to 1957 were concerned with ecological studies of the fox and its role as a rabies vector in the State as reported

by Parker *et al.* (1957). This was followed by investigations on growth and age determination of the red fox (Linhart, 1961). These preliminary studies set the stage for consideration of other control methods.

Poisons for Control

Among the methods considered was the use of poison baits and cyanide-loaded "coyote getters." These were considered impractical because poisons of any kind would be too dangerous to domestic animals and people since a large part of New York's fox range is in areas where public contact could not be avoided.

Disease for Control

Another consideration was the introduction of disease to which foxes are susceptible, such as mange or distemper, into areas of high fox density. This also was rejected as a control method because of the potential danger of creating side-effect problems worse than a rabies outbreak. Two related problems were also recognized: first, the danger of an unselective disease agent becoming established in other than the target species; and second, the vast public relation problems involved. Disease, especially mange, is constantly contributing to fox population control in the State; however, the occurrence and timing of this natural control are as yet unpredictable.

Chemical Reproduction Inhibitors for Control

Background preparations for investigations of chemical reproduction inhibitors began in 1960 when the subject was discussed with Dr. Robert K. Enders of Swarthmore College. In his work at USDA Experimental Fur Farm near Saratoga, Dr. Enders had discovered that the synthetic estrogen, diethylstilbestrol, inhibited reproduction among silver foxes when administered in some dosages at certain times prior to or during the estrous cycle. A field test of the effect of DES (diesthylstilbestrol) on a wild fox population was made during the winter of 1961-62. The results were inconclusive, chiefly because the DES was not assimilated by foxes from the baits which they consumed. The DES was in a pellet form which apparently passed through the animals without breaking down. As a consequence, S. B. Linhart, with Dr. Enders as a consultant, conducted a study of the effect of DES on caged foxes. This indicated that DES administered to vixens at a time ranging from 9 days before mating to 10 days after mating successfully inhibited production of offspring (Linhart and Enders, 1964).

In 1963 a three-year grant was received from the National Institutes of Health to carry out more extensive investigations of the effectiveness

of various reproduction inhibiting compounds on foxes. This grant has been administered cooperatively by the New York State Conservation Department and the New York State College of Argiculture at Cornell University under the direction of Dr. E. L. Cheatum, Director of the Division of Fish and Game, as principal investigator and Dr. William Hansel, Professor of Animal Physiology, as co-principal investigator. Following is a brief progress report on the studies conducted both directly and indirectly under this grant.

SCREENING POSSIBLE INHIBITORS The ideal inhibitor would be a single compound or combination of compounds one dose of which would effectively inhibit reproductive processes in either male or female foxes. Screening studies to determine the best suited compound were carried on at Cornell under the direction of Dr. Alan M. Bowerman, an animal physiologist. Commercial fur-farm-bred silver foxes, a color phase of the red fox (*Vulpes fulva*) derived by selective breeding, were used. These animals were considered easier to work with than captive red foxes because of their semi-domestic background.

The following compounds were administered to female foxes at various times before and after mating:

1. diethylstilbestrol (DES) —a synthetic estrogen
2. 17-ethynyl estradiol, 3-methyl ether (mestranol) —a synthetic estrogen
3. 1-(p-B-diethylaminoexthoxyphenyl)-1,2-diphenyl-2-chloroethylene (clomiphene) —a mixture of an 'A' isomer which acts as an estrogen and a 'B' isomer which acts as an anti-estrogen
4. 6-chloro-Δ^6-17-acetoxyprogesterone (CAP) —a synthetic progesterone

When these compounds were fed in a meat-base diet, the results indicated DES to have the greatest potential as a fox reproduction inhibitor in terms of cost and effectiveness. In the initial work with DES, a unit dose of 50 milligrams was used. Some of the experimental foxes were fed a single unit dose; others were fed the unit dose daily for different periods; and others were fed the unit dose weekly for different periods. When given as a single dose, DES was nearly 100 per cent inhibitory during the first 10 days after mating, but it was largely ineffective before or after that interval. In subsequent work, single doses as small as 12.5 milligrams proved equally effective. Similar results were obtained with mestranol, but this compound is too expensive for practical use. Clomiphene gave promising results when fed weekly during the breeding season, as did the 'A' and 'B' isomers used separately. CAP inhibited reproduction when fed in multiple doses throughout the normal breeding sea-

son and about 2 weeks thereafter. CAP inhibits estrus and mating, while the others inhibit fertility subsequent to mating.

Although DES effectively inhibited reproduction in caged foxes when fed in meat, subsequent studies showed the compound to be relatively ineffective when fed in rendered animal tallow even at higher dosages. Further laboratory and field studies are needed to determine a medium for administration which will allow effective assimilation of the inhibitor and still be acceptable by foxes.

Compounds administered to male foxes included DES, mestranol, clomiphene, busulphan, tretamine and 5-nitro-2-furaldehyde semicarbazone. They had little or no effect on spermatogenesis as determined by histological examination of testis biopsies. However, studies conducted during the winter of 1966-67 showed a complete inhibition of spermatogenesis when a mixture of equal parts of DES and CAP was fed at weekly intervals. The complete absence of epididymal sperm 4 weeks after the drug was last fed indicated that the resulting infertility will persist at least that long.

Field Testing Baits During the winters of 1960-61, 1961-62 and 1962-63 rabies-control trappers had conducted field tests for fox acceptance of several baits and bait mixtures that might be used to disseminate reproduction inhibitors among wild foxes. Among the baits tested were limburger cheese, beef fat, crackling mixture, venison, rendered cattle tallow, and a commercial fox bait. The results indicated that no one bait tested was preferred by foxes (Linhart, 1964). Field tests of various baits for fox preference and seasonal acceptance were continued during the winters of 1963-64 and 1964-65 as a portion of the responsibility assumed by the Conservation Department under the NIH grant. Testing was limited to two types of bait; one was a mixture of commercially rendered sheep, beef and pork tallow, and the other was the same tallow mixture blended with a commercial honey bait-fox mixture.[1]

Data from Linhart's (1964) work indicated a good degree of fox acceptance for both these types of bait. In addition, they were chosen because of the relative ease of manufacturing individual baits. The high tallow content and corresponding low melting point of both types allows the ingredients to be easily melted and poured into ½-ounce paper souffle cups. A single feather is then placed in each cup before the contents solidify. Dipped in fox lure prior to distribution, the feather serves to attract foxes to the bait. The paper souffle cups make convenient bait holders and allow ease of distribution for field testing.

Bait distribution was made at stations selected at likely fox crossings along secondary highways. The feathers of all baits were dipped in

[1] The honey bait consisted of honey and proportions of Tonkin musk, beaver castors, muskrat anal glands and spices known only to the manufacturer.

fox lure, and three cups of each type of bait were placed at each station with a 10-foot interval between the two types. The number of animal visits and the number of baits consumed were recorded daily. Track identification of the visiting species was made when snow conditions were favorable.

The results of the work done in 1963-64 and 1964-65 indicated a distinct preference by red foxes for the honey-tallow baits over the plain tallow baits (2.4:1 ratio), but no preference by gray foxes (1:1 ratio). Red fox preference for honey baits was further indicated by instances where only one type of bait was consumed even though both were present. In such cases, honey baits were selected 123 times versus 25 times for plain tallow baits (5:1 ratio).

DETERMINATION OF BREEDING SEASON AMONG WILD FOXES During the winters of 1962-63, 1963-64 and 1964-65, reproductive tracts of

TABLE 4. CONCEPTION DATES FOR FEMALE RED FOXES IN NEW YORK DURING 1963, 1964 AND 1965

Year	Number specimens	Conception date	
		Mean	Range
1963	18	January 20	December 14–February 15
1964	27	January 20	December 27–February 7
1965	22	January 28	January 4–March 1
Total	67	January 23	December 14–March 1

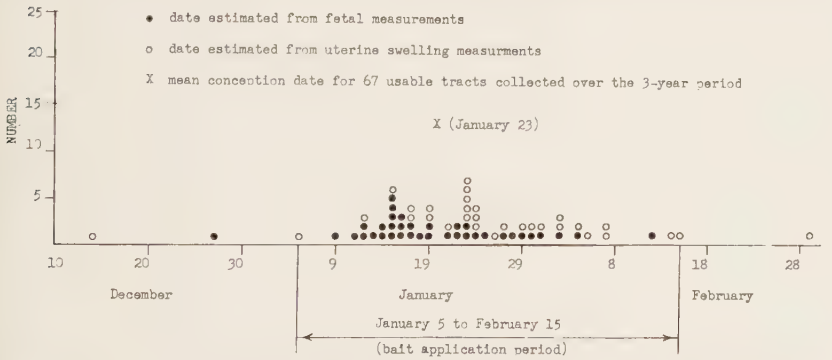

FIGURE 1. Distribution of estimated conception dates for the red fox as derived from examination of reproductive tracts collected during 1963, 1964 and 1965.

female red foxes were obtained from cooperating sportsmen, county sheriffs and other sources in central and western New York. For each, the date and location taken, corpora lutea scar counts, and weights and measurements of any fetuses present were recorded. Conception dates were determined by backdating from fetal and embryo measurements. Fetuses at or beyond the 30th day of development were aged by length and weight measurements according to the findings of Layne and McKeon (1956). Uterine swelling measurements recorded for caged silver foxes and red foxes were used to determine the age of embryos from the 15th to 25th day of development. The mean conception dates derived from these limited data were January 20 for both 1963 and 1964, and January 28 for 1965. Of the 67 tracts involved, 64, or more than 95 per cent, fell within a range of January 5 to February 15 (Table 4 and Figure 1).

Physiological Marker for Identifying Animals Consuming Baits The need for a method of marking animals, specifically foxes, that consume baits containing reproduction inhibitors was noted by Linhart (1964) as essential for evaluating the effectiveness of these inhibitors in the field. Investigations were begun in New York during 1964 to find a physiological marking agent which would be satisfactory. Screening was conducted in laboratory rats by feeding the compounds mixed in tallow baits. The two most promising compounds tested, Alizarin Red S[2] and tetracycline hydrochloride (or achromycin)[3], were then studied further.

In laboratory rats Alizarin Red S stained the molars a dark pink to red color which was easily identified up to 106 days after the chemical was administered. Achromycin produced a yellow fluorescence in the mandibles and humeri that was easily identified under ultraviolet light for at least 190 days. These two physiological markers were then tested on captive red foxes. Alizarin Red S was ineffective, but achromycin distinctively marked four of the five animals in the group.

Two dosages of achromycin were then tested on two groups of five foxes each. The first group received single baits containing 100 milligrams of achromycin. One animal did not eat the bait. Three of the four that did were effectively marked. The foxes in the second group received two baits, or 200 milligrams, each. Again one animal did not eat the bait, but the four that did were all effectively marked.

Field Tests of Baits Containing DES and Achromycin A field test to determine the effect of DES and achromycin on wild fox populations as conducted during the winter and spring of 1965-66. Two areas, one in Seneca County (44 square miles) and the other in Yates

[2] Supplied by the National Aniline Division of Allied Chemical Corporation, New York, N.Y.
[3] Supplied by American Cyanamid Company, Princeton, New Jersey.

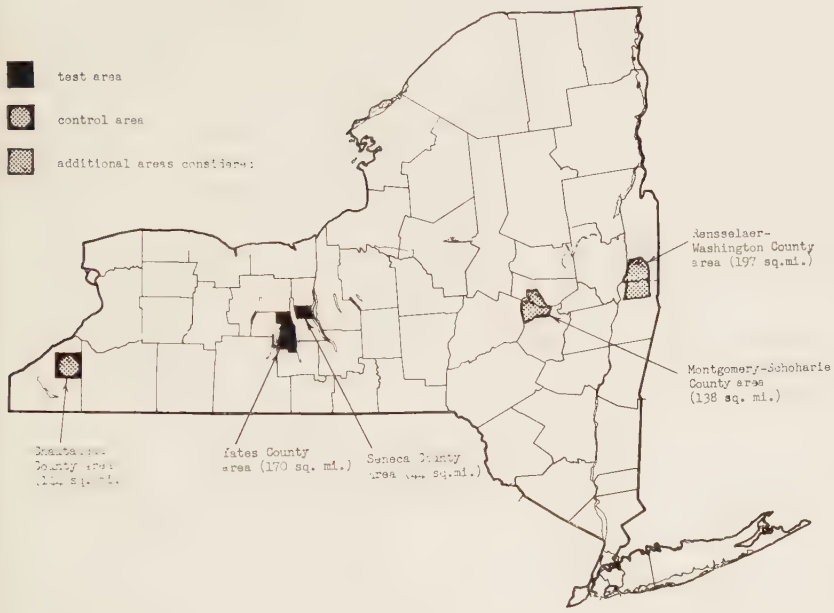

Figure 2. Location of rabies research field test areas. Fox population index surveys were made on all five areas in October 1965.

County (170 square miles), were selected for the test areas to receive baits containing both DES and achromycin. A third area (144 square miles) located in Chautauqua County was selected as the control area where baits containing only achromycin were distributed (Figure 2). These areas were selected because they had comparatively high fox population densities as determined by a modification of the scent post census technique described by Cook (1949).

Bait stations were set up at an approximate density of one per square mile by experienced rabies control trappers. At each station, five honey baits containing DES and achromycin were distributed on five occasions. The first distribution was made January 5, and the remaining four at 10-day intervals through February 14. The period of distribution was selected to coincide with 95 per cent of the fox conception dates estimated from reproductive tract collections. The 10-day intervals of bait distribution were selected on the basis of findings for caged foxes; DES was most effective within 10 days after conception. Baits containing only achromycin were distributed on the control area at the same time and by the same method as ones used on the test areas.

Trappers were instructed to pick up any baits that remained at the bait stations 5 days after the last distribution on February 14. However, snow conditions prevented full recovery of baits at that time, and the trappers were further instructed to pick up any baits left in April

just prior to establishing trap lines for collecting specimens on the study areas. Although the DES in the baits would have had only temporary inhibiting effects on domestic animals, picking up surplus baits was an added precaution against possible adverse public relations.

From April 15 to May 15, the trappers collected foxes, skunks, raccoons and opossums from the same sections of the study areas they had been assigned for bait distribution during the winter. A portion of the Seneca County area was not covered by this time, so trapping was continued there from June 1 to June 20. Unfortunately, a low number of female foxes was taken on the test areas, and because of this the effectiveness of DES as an inhibitor of reproduction in wild fox populations was not determined during this study.

The low take apparently resulted from an outbreak of sarcoptic mange which substantially reduced red fox numbers on the larger test area. The presence of mange was not detected until it was too late to change the test area locations. Its effect is illustrated by the total catch of only 20 red foxes (9 females), compared with 17 gray foxes (7 females), a nearly 1:1 ratio, during 30 days of trapping on the 170-square-mile Yates County area. During the October survey, a high red fox population density was recorded on this area, while the number of gray foxes was low. The gray fox is apparently not affected by this disease.

Achromycin, the physiological marking agent included in both treated and untreated baits, proved to be satisfactory for marking wild foxes and apparently for marking other species collected as well. Ap-

Table 5. Effectiveness of Achromycin as a Means of Physiologically Marking Wild Foxes*

Item	Area			Total
	Chautauqua	Seneca	Yates	
Female				
Number captured	56	10	16	82
Number marked	35	8	8	51
Percentage marked	62.5	80.0	50.0	62.2
Male				
Number captured	36	13	21	70
Number marked	28	10	14	52
Percentage marked	77.8	76.9	66.7	74.3
Total				
Number captured	92	23	37	152
Number marked	63	18	22	103
Percentage marked	68.5	78.3	59.5	67.8

* Includes both red fox and gray fox.

proximately 68 per cent of all the foxes trapped had been marked by this compound. A higher proportion of males than females was marked (Table 5), but the difference was not significant as determined by a chi-square test ($\chi^2 = 1.43$). Evaluation of the data for the other species marked (skunk, raccoon and opossum) has not been completed.

DISCUSSION

The State program for controlling rabies in wildlife, carried on since 1946, has neither eliminated rabies nor prevented its spread. However, the reduction achieved in fox population density has apparently lessened the incidence of rabies and subdued the disease for several years in some areas. That recent rabies outbreaks have not reached epizootic proportions, even with rabies endemic throughout the State, indicates a degree of successful control. A more accurate, yet economical, technique for determining fox population densities is needed to facilitate efficient planning for control trapping.

County trapping programs have shown limited success in reducing the incidence of rabies in some instances, but, except from a public relations point of view, post-outbreak trapping has been ineffective. Bounty payments by counties have been the least successful; State trappers often catch more foxes in such counties than in comparable areas where no bounty is paid.

The results of research on reproduction inhibitors for controlling fox abundance are promising. But further field testing, as well as additional laboratory work with other compounds, are needed.

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EFFECT OF DIFFERENT FERTILIZERS ON YIELD OF GOLDEN SHINERS IN NEW YORK PONDS[1]

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ABSTRACT

Six ponds were stocked with adult golden shiners in 1953, and different fertilizers were applied. Heavy applications of inorganic fertilizers produced earlier and more pronounced plankton blooms than did lower applications in combination with manure, but standing crops in all ponds were similar at the end of one growing season. During the second year plankton blooms were consistently low in all ponds, whether fertilized with phosphorus and nitrogen or with phosphorus alone. However, the standing crop in all fertilized ponds increased from about 200 to 500 pounds per acre between the first and second growing seasons. At the end of 2 years, standing crops in the fertilized ponds were about three times that in an unfertilized control pond.

Fertilization of ponds in the northern United States has been shown to greatly enhance production of plankton and benthos (Ball, 1949; McIntire and Bond, 1962). Unfortunately, increased fish production has not always been attained (Ball, 1949) and the value of fertilizing farm ponds stocked with game fish in northern states has been questioned (Bennett, 1952).

Fertilizers are frequently applied to New York ponds to increase fish production. Regier (1963) compared the standing crops of bass and bluegills in ponds fertilized at different rates. Mean standing crops were generally higher in ponds receiving the heaviest applications of fertilizer. But, differences in standing crop were not pronounced, and the low rate of harvest did not appear to justify the cost of fertilization.

Fertilization may be more applicable to bait-fish ponds where harvest is intensive and the crop has a monetary value. This paper describes the effect of different fertilizers and rates of application on the yield of golden shiners (*Notemigonus crysoleucas*) in a group of ponds located in the Lake Plains region of New York State.

DESCRIPTION OF PONDS AND APPLICATION OF FERTILIZER

The group of ponds studied, located 5 miles south of Geneva, consisted of a 4.5-acre pond (Pond 4, Table 1) with a maximum depth of 7 feet and six smaller ponds between 0.21 and 0.25 acre in area with a maximum depth of 5 feet. The small ponds were constructed in 1952, and water was supplied independently to each of them from a control box in the larger pond. The larger pond was constructed in 1951, and the water level was maintained by runoff.

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[1]A contribution of Federal Aid in Fish and Wildlife Restoration Project F-17-R.

An initial application of manure and inorganic fertilizer (5-10-5) at rates of 1,000 to 100 pounds per acre, respectively, was made in all six small ponds during April 1953. Beginning May 5, regular applications of fertilizer were broadcast over these ponds at approximately 2-week intervals through August. Three ponds (Ponds 7, 9, and 10) chosen at random were fertilized with 5-10-5 at a high rate and three (Ponds 5, 6 and 8) received smaller applications of 5-10-5 supplemented with manure. Pond 10 was not fertilized during one period in July to reduce the possibility of fish mortality from depletion of oxygen during an intense plankton bloom. Pond 4 constituted a control and was not fertilized.

The six experimental ponds were stocked with adult golden shiners in April 1953, and spawning occurred from May through August. They were drained and refilled in October 1953 and again in April 1954 to determine the standing crop. Oxygen depletion during the winter of 1953-54 killed most of the fish in Ponds 9 and 10. Experiments were continued in the remaining four ponds, and during 1954 two of these were fertilized with 12-12-0 and two with 0-12-0.

RESULTS

Phytoplankton blooms occurred during June and July of 1953 in Ponds 7, 9 and 10 which received the highest applications of inorganic fertilizer (Figure 1). Fertilization of Ponds 6 and 8 with smaller amounts of inorganic fertilizer together with supplemental applications of manure did not produce a noticeable plankton bloom until late summer, and in Pond 5 secchi disk transparency readings were consistently over 30 inches.

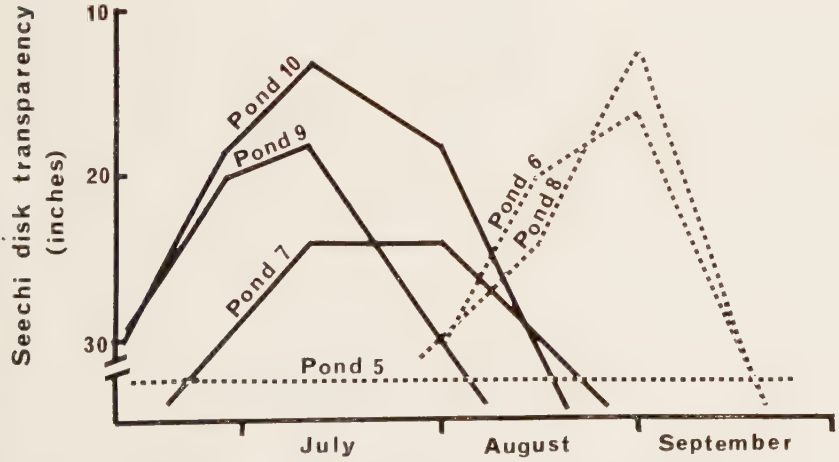

Figure 1. Variation in secchi disc transparencies in the experimental ponds during 1963.

Beds of filamentous algae developed in Ponds 5, 6 and 8 which were fertilized with manure. Swingle (1947) suggested that organic fertilizers such as were used in these ponds may be more readily available to filamentous algae than to planktonic algae, but greater light penetration to the bottom of Ponds 5, 6 and 8 during early summer could also have accounted for the growth of filamentous algae.

The ponds were drained in October 1953, and the weight and number of golden shiners over 1.8 inches long were determined (Table 1). Standing crops in Ponds 5, 6 and 8, which received regular applications of manure, averaged 208 pounds per acre compared with 176

Table 1. Standing Crops of Golden Shiners in 1953 and 1954 for Ponds Receiving Different Fertilizer Treatments*

Pond	Standing crop per acre					Fertilizer	
	Pounds	Number by inch-size class				Pounds per acre	Type
		1 – 2	2 – 3	3 – 4	4 – 6		
October 1953							
5	180	4,400	38,800	..	..	300 2,800	6–12–6 manure
6	191	1,540	42,340	..	..	300 2,800	6–12–6 manure
8	252	21,270	59,460	..	..	300 2,800	6–12–6 manure
7	198	43,500	15,060	4,160	..	640	6–12–6
9	170	2,170	16,020	10,280	..	640	6–12–6
10	160	..	3,270	12,830	..	570	6–12–6
October 1954							
5	332§	..	15,200	18,000	..	1,100	12–12–0
6	515	..	37,340	21,180	..	1,100	12–12–0
8	529	..	24,900	27,520	..	1,100	0–12–0
7	474§	..	26,210	29,120	..	1,100	0–12–0
4	145	..	5,790	5,790	670	none	xxx

* Data from separate experiments.

§ During July, 316 pounds per acre of golden shiners were harvested from Pond 5 and 189 pounds from Pond 7.

pounds per acre in Ponds 7, 9 and 10 which received inorganic fertilizers only. Differences in fishproduction can probably be attributed to phytoplankton blooms which may have suppressed reproduction of golden shiners during early summer in Ponds 7, 9 and 10. Samples of golden shiners from Ponds 9 and 10 showed a bimodal length-frequency distribution indicating spawning was interrupted in June and July. Golden shiners frequently fail to spawn in ponds with low transparency and a lack of submergent vegetation (Forney, 1957). This reduced the total standing crop, but golden shiners hatched before July grew rapidly because of reduced competition.

In the spring of 1954 four of the ponds were again drained, and the golden shiner populations were adjusted to obtain a fairly uniform weight of 180 to 196 pounds per acre. Fertilizers was applied at 2-week intervals from May through August. Ponds 7 and 8 received a total of 1,100 pounds per acre of phosphate (0-12-0), and Ponds 5 and 6 were fertilized with the same quantity of phosphate and an equal quantity of nitrogen (12-12-0). During 1954, secchi disk transparencies were consistently over 30 inches, and extensive growths of filamentous algae and higher aquatic plants developed in all ponds.

The ponds were drained in October 1954 to determine the weight and number of golden shiners. Standing crops in Ponds 6 and 8 were over 500 pounds per acre. Standing crops were somewhat lower in Ponds 5 and 7 since part of the population had been removed in July, but there was no evidence that the type of fertilizer used had any effect on the yield of fish.

The 4.5-acre control pond adjacent to the experimental ponds was stocked with golden shiners in 1951. This pond had not been fertilized, nor had any fish been removed prior to the time it was drained in October 1954. The standing crop in this unfertilized pond was 145 pounds per acre compared with an average of 522 pounds in Ponds 6 and 8. The difference in size of the unfertilized and fertilized ponds may partly explain the differences in yield. However, in three other unfertilized ponds in central New York that were studied during the same period, the average standing crop was only 100 pounds per acre after 2 years.

DISCUSSION

There was approximately a threefold difference in the standing crop of golden shiners between the fertilized ponds and the unfertilized control pond at the end of two growing seasons. Ball (1949) found much smaller differences between fertilized and unfertilized ponds stocked with bait fish in Michigan, but he measured the standing crops after 1 year. The effect of fertilization on fish production in northern ponds stocked with fry or adults may be difficult to detect after one growing season

since the low biomass of fish produced during a short growing season may not fully utilize the increased food resulting from fertilization. The three- to four-fold increases in yield after 1 year attributed to fertilization of Alabama ponds (Swingle, 1947) are comparable to results attained in New York ponds after two growing seasons.

Addition of phosphorus was apparently responsible for the increased fish production, and applications of nitrogen in combination with phosphorus did not appear to increase yield. High secchi transparency indicated that phytoplankton density was low in ponds fertilized with nitrogen and phosphorus as well as in those receiving only phosphorus. Nitrates in combination with phosphorus did not appear to have any beneficial effects over phosphorus alone in this study, and McIntire and Bond (1962) were unable to demonstrate any increase in plankton or bottom fauna when only nitrogen was applied. As noted by Mortimer (1954) the use of nitrogenous fertilizers in American fishpond practice is largely based on experiments by Swingle and Smith (1938) with algae cultures in jars and tanks, and the value of nitrogen has not been adequately documented in ponds.

Heavier application of inorganic fertilizers produced blooms earlier in 1953 than did lower applications of inorganic fertilizers with additional manure. It is doubtful that the same fertilizer treatments would produce similar differences in response during a second year. Fertilization of new ponds frequently produces phytoplankton blooms, but in older ponds in New York fertilization generally increases filamentous algae and higher aquatic plans. Despite the absence of any obvious phytoplankton blooms in the ponds during 1954, fish production was enhanced by fertilization.

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GENERAL NOTES

SEX COMPOSITION OF STRIPED BASS FROM THE LONG ISLAND SURF[1]

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While Vladykov and Wallace (1952) reported that the population of striped bass inhabiting Chesapeake Bay was about equally divided between males and females when sampled from August to November, they observed that the proportion of males increased considerably in winter and spring. They noted that males comprised 83 per cent of the population during March of 1938. Similar observations were made by Pearson (1938) and Merriman (1941) who both reported many more mature males than females on the spawning grounds. The latter investigator, for example, found that, of 127 striped bass examined at Weldon, North Carolina (Roanoke River) during the 1938 spawning season, 121 were males.

To the contrary, however, Merriman (1941) reported that, of 676 striped bass examined from Long Island and New England waters during 1936 and 1937, less than 10 per cent were males. From this he hypothesized that, since the males mature at an earlier age than the females, many young males (2 or 3 years of age) probably remain behind in Chesapeake Bay to spawn while the immature females of the same age groups migrate northward where they constitute a major portion of the population. Merriman (1941) also reported that, while 11.8 per cent of the 2-year-old fish were males, only 4.4 per cent of those 3 years old or more were males and that no males were found among those older than 4 years in northern waters. He further concluded from this that "the percentage of males apparently decreases in the age categories above the 2-year-olds."

These observations prompted the author to gather data on the sex composition of the striped bass population inhabiting the surf on the south shore of Long Island during 1964. Specimens were collected with a 1,300-foot modified commercial beach seine from the ocean along the outer barrier beach (Great South Beach) near Smith Point County Park. The seining site, gear and methods of operation were described by Schaefer (1967). Sampling was carried out on 31 dates between April 27 and November 24.

Following capture, each fish was measured to the nearest 5 millimeters in fork length, and its sex was determined by gross examination of the gonads. Those that were immature, i.e., whose sex could not be determined by visual inspection, were discarded. Scales were taken from arbitrarily selected specimens of large size (600 millimeters or more in fork length) for age determination.

TABLE 1. SEX COMPOSITION OF STRIPED BASS COLLECTED ALONG GREAT SOUTH BEACH IN 1964

Size group (millimeters)	Number			Percentage of males
	Male	Female	Total	
275–399	12	47	59	20.3
400–599	82	466	548	15.0
600–974	17	151	168	10.1
Total	111	664	775	14.3

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R.

A total of 787 striped bass, ranging in size from 275 to 974 millimeters in fork length, were collected. Except for 12 small (275 to 395 millimeters) examples, sex was determined for all specimens. The data are presented in Table 1 according to three size groups. Only 14 per cent of the 775 sexed specimens were males. Furthermore, the proportion of males decreased as fish size increased. This decrease, however, was demonstrated by chi square analysis to be nonsignificant ($\chi^2 = 4.38$, d.f. $= 2$).

Males of the large size category ranged in age from 4 to 9 years. The largest male collected was 850 millimeters in fork length and 9 years of age.

These findings seem to corroborate those of Merriman (1941), i.e., that the proportion of male striped bass in the population which migrates northward along the Atlantic coast is low. It should be noted, however, that the proportion recorded in the present study was significantly higher ($t = 2.66$, d.f. $= 1{,}449$) than that reported by Merriman (1941) for Long Island and New England waters. On the other hand, while the proportional difference between the number of males occurring among 2-year-old (58 of 493) and 3-year-old and older (8 of 183) striped bass collected by Merriman was significant ($t = 2.88$, d.f. $= 674$), the present data revealed no significant reduction in the percentage of males as fish size (and, therefore, age) increased.

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YELLOW FAT DISEASE IN MUSKRATS[1]

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Yellow fat disease (nutritional panniculitis or steatitis) is a noncontagious disease that has been found in pigs, cats and rapidly growing kits of ranch mink. It is caused by unsaturated fatty acids in the diet that become rancid and toxic and destroy primarily vitamin E (an antioxidant) *in vivo*. The foods involved usually consist of fish or fish products stored for long periods of time or improperly and incompletely frozen. In mink and cats the disease is characterized by a "puffy" condition, reluctance to move and rapid death. Postmortem examination reveals subcutaneous edema and an orange to lemon-yellow color of all adipose deposits of the body. Acid-fast staining of tissue sections shows a pigment called "ceroid" in the interstitial spaces of fat cells. This pigment is believed to be a metabolic artifact and may be related to fish oils in some property other than rancidity (Jubb and Kennedy, 1963—pp. 513-514).

In February 1966, a muskrat trapper in Albany County (N.Y.) reported finding yellow fat under the hides and on the carcasses of muskrats (*Ondatra zibethica*) taken from one small pond. Muskrats removed from other ponds in the area did not show this condition. Although the pelts on removal from affected muskrats had a yellow subcutaneous surface, the color of the hide returned to normal after about a week of air drying. After a number of pelts and carcasses taken by the trapper had been seen, field observations and live trapping were instigated at the pond to gather more information on the possible etiology of the condition.

The pond was about 4 acres in size with a depth from 1 to 20 feet. There was one small inlet (about 3 feet across and up to 6 inches deep) and one outlet consisting of a 24-inch pipe in a constructed concrete dam. A 28-inch pipeline entered the pond from drainage of a nearby residential area. The water level of the pond was relatively stable all year. An enormous amount of bottom growth occurred in spring and summer, together with algae along the banks, not unlike many ponds in the area. The water was generally a murky brown color, except in July and August when it appeared very green. Near the pipeline entering the pond, reddish deposits that may have been iron from the pipe were evident. Fish life in the pond consisted of a few minnows.

Specimens submitted by the trapper were autopsied, and various tissues were placed in 10 per cent formalin, embedded in paraffin, sectioned, and stained with hematoxylin and eosin. Sections of fat tissue were further stained for acid-fast pigment.

Live trapping of muskrats was attempted, but only two of six caught were taken alive; the remaining four drowned. The drowned specimens were autopsied, and histological tissue sections were examined. The two muskrats caught alive were anesthetized with ether, and the inguinal region was incised to observe the subcutaneous fat. Following surgery, the animals were placed on a diet of commercial laboratory rat pellets supplemented with fresh greens. Approximately 2 weeks later, the surgery was repeated to observe any change in fat coloration.

Muskrats collected from other areas of New York were used as experimental animals in an attempt to reproduce the disease. These animals were examined for "healthy" fat by subcutaneous surgery prior to experimentation. Commercial cod liver oil was subjected to numerous methods of causing rancidity. Although inoculated with bacteria and subjected to various temperatures, it is questionable if the oil became truly rancid. This "rancid" oil was mixed with commercial laboratory rat pellets and fed to the muskrats. Following this procedure, water from the suspect pond was collected and given to the muskrats as their only source of water.

Eight of 14 muskrats taken by the trapper and three of six of those trapped by project personnel had a pale lemon color to the underside of the hide and to

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the fat in the body depots. However, not all of these animals were available for detailed studies. Postmortem examination of the affected muskrats revealed animals with little to moderate amounts of fat in the body depots. Many were smaller than average for the time of year they were trapped. Subcutaneous edema was usually prominent when the hide was removed, and the subcutaneous fat was hard and lumpy and tended to shatter when incised. Histopathological examination of tissues from the affected muskrats revealed slight acid-fast pigment in the interstitial spaces of fat cells in only one specimen. Some round cell infiltration of the interstitial spaces of fat cells was evident, but fibrosis was not a remarkable feature. No neutrophilic infiltration of adipose tissue was observed. The remaining visceral organs were essentially normal.

Live-trapped animals, found by subcutaneous surgery to have yellow fat and subsequently placed on a commercial laboratory rat diet, had normal-appearing fat at the end of a 2-week period.

Animals fed "rancid" cod liver oil failed to produce the yellow fat syndrome seen in field cases. However, animals given water from the pond as their only water source did show yellow fat at autopsy.

This investigation was begun when it was learned that muskrats in only one of many ponds in the area being trapped had a yellow fat syndrome. Observation of raw sewage in this one pond had a possible public health implication. That muskrats showed yellow fat at capture and then normal-appearing fat after a 2-week diet of laboratory rat food suggests that the condition is nutritional in muskrats as it is in the other species studied.

If the hypothesis is correct that the ceroid pigment is an artifact related to fish oils in some way other than rancidity and that the cellular infiltration in the tissues is in response to the pigment, the disease could occur if vitamin E were destroyed by a diet consisting of food other than fish or fish oils. That one muskrat showed slight ceroid pigment in the interstitial spaces of the fat cells indicates that some fish may have been involved in this one case. However, this was not a primary factor.

The lack of yellow fat produced in experimental animals fed rancid cod liver oil, if it was truly rancid, would indicate that this condition in muskrats is not analagous to the syndrome in other species. However, if the pathogenesis of the disease is as similar as the gross postmortem findings, it would be the first reported case of yellow fat disease in muskrats.

In either event, reproduction of the syndrome by using water from the pond did incriminate the pond. The fact that it contained raw sewage at the time definite yellow discoloration of muskrat hides was observed, and that normal coloration returned after the affected muskrats were removed from the pond, may suggest that polluted water plays a part in the condition although it is obvious other unknown factors may be involved. A year later (1967), raw sewage no longer contaminated the pond, and muskrats removed were essentially normal. However, the true etiology is still obscure.

The number of muskrats affected necessarily made this a limited study, but it seems worthwhile to call attention to the observations made. When yellow fat is observed in muskrats, any investigation should include the bodies of water, especially if they are small.

LITERATURE CITED

Jubb, K. V. F., and P. C. Kennedy. 1963. Pathology of domestic animals, 1st ed., Vol. II. Academic Press, New York and London.